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A Welding Data Dictionary

William G. Rippey
U. S. DEPARTMENT OF COMMERCE
Technology Administration
National Institute of Standards
and Technology
Intelligent Systems Division
Gaithersburg, MD 20899-8230

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U.S. DEPARTMENT OF COMMERCE
Donald L. Evans, Secretary

TECHNOLOGY ADMINISTRATION
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NATIONAL INSTITUTE OF STANDARDS
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Arden L. Bement, Jr., Director

A Welding Data Dictionary

Abstract
This data dictionary specifies data elements that are used to describe the design, fabrication and inspection of weldments. It comprises welding information from several authoritative sources. Data include description of component materials, details of joints and welds, and variables of the welding processes. The data dictionary provides, in one document, the welding information needed to develop format specifications for digital data that can be exchanged by computer programs.

Keywords
data dictionary, digital welding data, weld inspection results, welding procedure specification, welding terms, weldment design.

Foreword
In 1992, welding information formats were described in two American Welding Society (AWS) specifications, *AWS A9.1- Standard Guide for Describing Arc Welds in Computerized Material Property and Nondestructive Examination Databases*, and *AWS A9.2 - Standard Guide for Recording Arc Weld Material Property and Nondestructive Examination Data in Computerized Databases*. This document expands the scope of those documents and could serve as a core document if an AWS committee undertakes a new specification project. Current individual AWS specifications are rich in terms and data items describing materials, design and processes. This data dictionary gathers the information in a single document, to be used by data modelers with specific encoding formats in mind. Examples of format specifications are STEP and XML. The ultimate purpose is to facilitate exchange of welding data between application software programs developed by different vendors.

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A Welding Data Dictionary

Scope

This document includes data describing design of welded products, design of weldments including detailed weld and joint description, arc welding process specification, and destructive weld inspection. Common welding documents that convey this information are welding procedure specifications (WPSs) and mechanical testing reports. These documents are often implemented using hard copy or simple, but non-standard data formats. Variables of other welding processes such as gas and laser welding have not been covered at this time.

Some of the variables and data types needed in standard welding procedure specifications (SWPSs) and procedure qualification records (PQRs) are not addressed. Examples are ranges of allowed values (e.g., minimum and maximum allowed current), conditions that are expressly not allowed, conditions that are optional, or multiple conditions that are allowed. These should be straightforward extensions of the data elements and types already defined.

Also not addressed are overall formats for standard forms or standard test result reports. These are left to data modelers according to the requirements of their customers. Appendix 1 lists many other items that are not included in this document. They are suggestions to committees of experts who could expand the document's scope.

Purpose

A data dictionary is the starting point for developing specifications for data formats for digital welding data. It gathers relevant data in one place, establishes standard labels and descriptions of the items, and designates data types to them. The purpose of a standard data format is to enable independent computer programs (applications) to exchange information with minimal or no cost and effort.

This document's form is suitable for a formal standard to be used by many different manufacturing industries that use welding. The existence of a single data dictionary as source for data modeling will ease the challenge of gathering the welding knowledge, and make implementations of different formats more consistent. Example formats are STEP and XML. Consistency eases the challenge of converting between the differing formats should it be necessary. Easy conversion between formats makes the decision of which format to use less critical. When data modelers discover improvements to the model the changes can be reflected in the high level data dictionary as well as to the implementation being worked on at the time. This way other implementations can benefit from the improvement.

It is envisioned that welding standards documents that contain forms will use this data model to build their own structures to represent the form information. This will enable encoding of the information in a standard format so it may be conveyed electronically and not be limited to hardcopy or proprietary formats.

The data dictionary is written in English rather than a formal modeling language so that:

- welding experts can understand the information and work on it to improve it without learning a computer language.

- it can serve as the common ground between welding experts and the data modelers who will develop detailed specifications.
- it is not biased toward any particular encoding scheme.

This dictionary goes beyond presenting all elementary information units as a flat list. It suggests gathering of elements into frequently used groupings. These groupings are not rigid: data modelers or refiners of the data dictionary can ungroup or regroup as they see fit. The groupings present the information in recognizable units that make understanding the document easier.

This data dictionary is not sufficient to specify the design of a database or of a complete specification for standard data. Its terms and type definitions are the building blocks that need to be supplemented by encoding rules, and relationships like those described in database tables.

Source Documents

These documents contain definitions of the variables, or state the need for variables in report documents to describe welding products, processes or inspection results.

1. AASHTO/AWS D1.5M/D1.5:2002 – *Bridge Welding Code.*
2. ANSI/AWS A9.1-92, *Standard Guide for Describing Arc Welds in Computerized Material Property and Nondestructive Examination Databases.*
3. ANSI/AWS A9.2-92, *Standard Guide for Recording Arc Weld Material Property and Nondestructive Examination Data in Computerized Databases.*
4. ANSI/AWS A3.0: 2001, *Standard Welding Terms and Definitions.*
5. AWS B1.10:1999, *Guide for the Non-destructive Examination of Welds.*
6. AWS B2.1:2000, *Specification for Welding Procedure and Performance Qualification.*
7. AWS B4.0M:2000, *Standard Methods for Mechanical Testing of Welds.* Parts A, B and C were used. Parts D and E are not covered here.
8. AWS D1.1/D1.1M: 2002 *Structural Welding Code – Steel.* See especially Annex E, Sample Welding Forms.
9. Jefferson's Welding Encyclopedia, 18th Edition, American Welding Society, 1997.

Guidelines Used in Building the Data Dictionary

- The primary audience for this document is domain experts in welding. They must be able to understand its content and be able to refine and expand it, without needing computer programming experience. The document then becomes a bridge between them and computer experts, who will encode the data and manipulate it in computer programs that serve the welding experts.
- The item descriptions in this document should not be cited as formal definitions of terms. The descriptions are original, or are shortened or paraphrased versions of formal definitions. The source documents, usually AWS in origin, should be used.
- Sources of most definitions are AWS documents.
- When values are shown as "enumeration of:", this means that only the listed values are allowed. This is a restriction on the allowed values for the element.
- This data dictionary specifies, for some elements, hierarchical relationships of sub-elements, and enumerated values. Element grouping and enumeration are constraints on how the data can be used in a computer program or in a digital file. The constraints

promote increased consistency between different vendors' implementations of products or of digital format specifications.

- The element naming convention of lower case words separated by underscores was chosen to be human readable, and mildly suggesting future tags to be used in formal encoding. The convention is not intended to suggest a preference of one encoding method over another.
- Some provisions are made for specifying units for measured variables, especially to distinguish between U.S. customary, or "inch-pound", and International System of Units (SI) usage. More examination of the need and suggestions for values are needed from welding experts.

Sections of this Document

Weld Design Data describes the desired weld that joins two workpieces. It includes descriptions of the workpieces (e.g., thickness, material), the geometric relationship between the workpieces (e.g., tee, butt), the edge shapes of the workpieces to form a joint, and the desired properties of the weld, such as size and degree of penetration. There are usually several different ways to produce a designed weld, e.g., by varying ***Welding Process Data*** such as welding process, number of passes, thickness of consumable, gas composition, etc. ***Testing and Inspection Data*** is information gathered by measuring characteristics of the weld after it is made, usually to compare to the design data.

The appendices contain next-step information for data modelers, some high level background on the concept of standard data formats for welding, and suggestions for expansion of the scope of the next version of this data dictionary.

Dictionary Field Definitions

- There are two kinds of dictionary entries, "element" and "type". Types are data templates that are reused in multiple elements. The prefix "p:" means primitive, one of Boolean, string, integer or decimal. An element is a unique chunk of information used in describing welding. The distinction between types and elements will be further refined in detailed data modeling – the major criterion is to make the model concise and understandable.
- Diagram - When an element has subelements, a sketch of its sub-elements is shown to aid understanding. Diagrams show only one level of decomposition. Appendix 4 contains a few selected diagrams of multilevel diagrams. In the diagrams, the 3 short bars in some boxes is an artifact of the documentation tool and is not relevant. The small arrow in the lower left corner indicates that the element is defined globally, i.e. it is independent of the element definition it appears in.
- Type – enumeration is used when there is one choice from a list of simple values. *Choice of* is used when there are several non-simple elements, one of which must be picked.
- Values – this field appears only for enumerated types, showing the allowed values.
- Children – list of elements that are parts of this element.
- Used by – the name of elements that contain this element.
- Source – citation of a standard or industry handbook that lists the need for the information. When the source for a sub-element is the same as its parent element, the source information is not repeated.

- Description – prose description, or standard definition if one exists, to allow data modelers to select the appropriate elements for specific applications, forms and reports. It is an important task of welding experts, not data modelers, to develop precise descriptions.
- Underlined type and element names are links that can be used in electronic documents for easy jumping to definitions.

The index below is included for use in electronic documents that can use the links to the definitions. The types and elements are arranged in alphabetic order in each section.

Elements

base_metal
bend_test_bend_radius
connection
electrical_specification
filler_metal
fracture_crack_plane_orientation
fracture_energy_absorbed
fracture_machine_notch_position
fracture_specimen_location
gas_component
hardness_indentor
hardness_load
hardness_location_of_impressions
hardness_test_result
hardness_test_types
heat_treatment
joint_design
joint_penetration
mechanical_test
nick_break_apparatus
preheat_and_interpass
shear_test_shear_strength
shear_test_unit_shear_load
shielding_gas_for_procedure
sub_assembly
tension_test_data
test_fracture_appearance
test_fracture_location
test_LGBTFW_angle_of_fracture
test_LGBTFW_discontinuity
test_machine_serial_number
test_number_of_specimens
test_percent_elongation
test_postweld_mechanical_treatment
test_postweld_thermal_treatment
test_specimen_dimensions
test_specimen_location
test_specimen_orientation
test_technician_name
variables_specification
weld_details
weld_sizes

Types

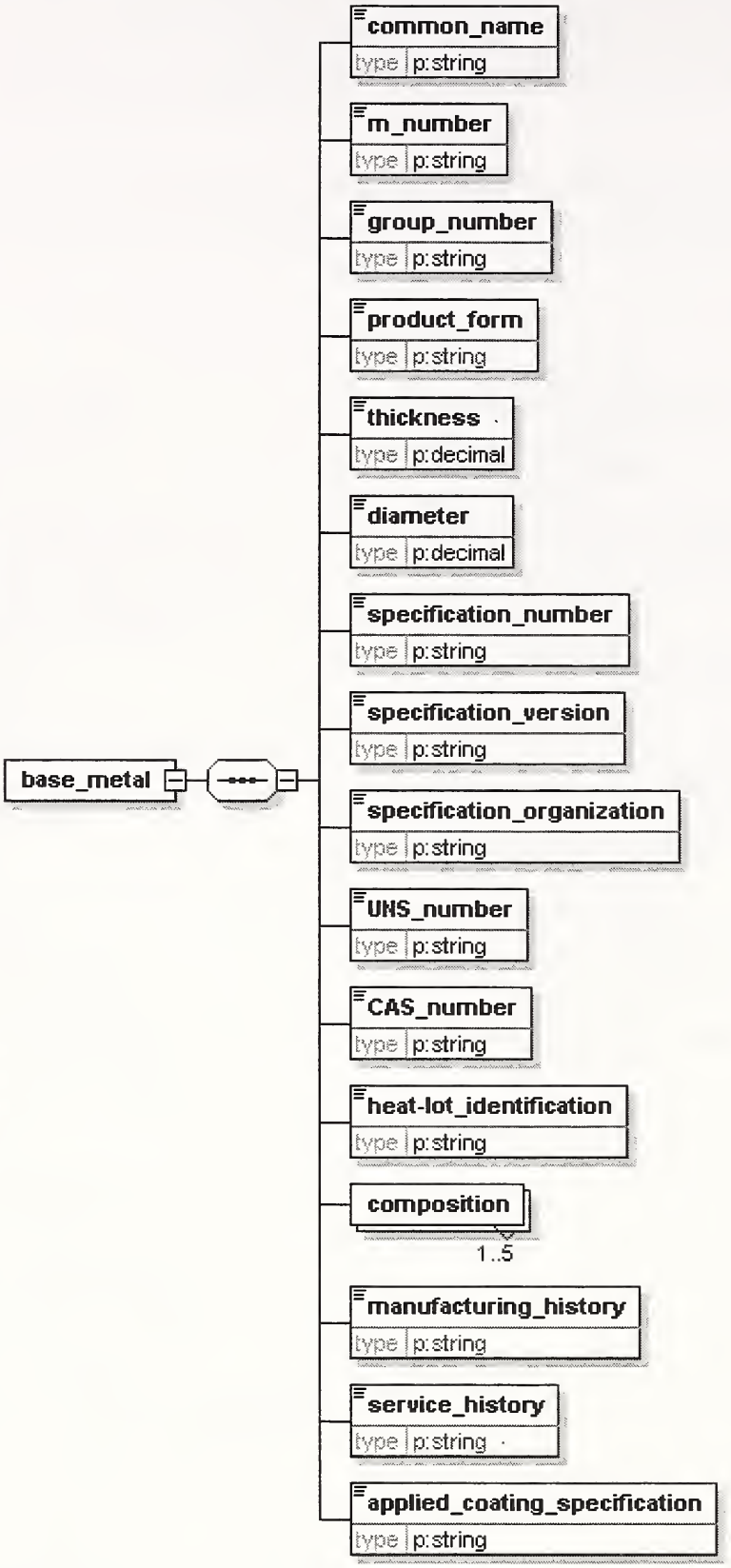
allied_processes
arc_welding_processes
bend_test_types
brazing_processes
edge_shapes
fracture_toughness_test_methods
fracture_type_of_test_equipment
gas_flowrate_type
joint_types
linear_dimension_range_type
linear_dimension_type_mm
mechanical_tests
other_welding_processes
oxyfuel_gas_welding_processes
resistance_welding_processes
shear_specimen_types
shielding_gas_type
soldering_processes
solid_state_welding_processes
soundness_test_types
temperature_type
tension_specimen_types
test_temperature
weld_types
welding_process_type

welding_position
welding_procedure_specification
weldment
workpiece

1. Weld Design Data

1.1 element **base_metal**

Diagram



Children **common_name m_number group_number product_form thickness diameter specification_number specification_version specification_organization UNS_number CAS_number heat-lot_identification composition manufacturing_history service_history**

	applied_coating_specification
Used By	element **welding_procedure_specification**
Source	AWS B2.1, section 2.13.
Description	The material that is being joined using a weld.

*1.1.1 element base_metal/**common_name***

Type	p:string
Description	The trade name, a name used without all the designations of the formal specification.

*1.1.2 element base_metal/**m_number***

Type	p:string
Source	AWS A9., section 5.1.1., and B2.1, glossary definition p. 2.
Description	A designation used to group base metals for procedure and performance qualifications.

*1.1.3 element base_metal/**group_number***

Type	p:string
Description	A classification system for metal by material properties.

*1.1.4 element base_metal/**product_form***

Type	enumeration of p:string
Values	enumeration plate enumeration bar enumeration sheet enumeration tube enumeration pipe enumeration structural - i beam enumeration structural - other
Description	The form of the workpieces to be joined.

*1.1.5 element base_metal/**thickness***

Type	p:decimal
Description	Plate or sheet thickness, if tube, specifies wall thickness.

*1.1.6 element base_metal/**diameter***

Type	p:decimal
Description	Outside diameter, only used if material is tube.

*1.1.7 element base_metal/**specification_number***

Type	p:string
Source	AWS A9.1, section 5.1.1
Description	The standard designation of the formal material classification.

*1.1.8 element base_metal/**specification_version***

Type	p:string
Source	AWS A9.1, section 5.1.1
Description	Version of the specification used.

*1.1.9 element base_metal/**specification_organization***

Type	p:string
Source	AWS A9.1, section 5.1.1
Description	The organization responsible for generating the specification.

*1.1.10 element base_metal/**UNS_number***

Type	p:string
Source	AWS A9.1, section 5.1.1
Description	Unified Numbering System for Metals and Alloys, managed by ASTM and SAE.

*1.1.11 element base_metal/**CAS_number***

Type	p:string
Source	AWS A9.1, section 5.1.1
Description	Chemical Abstracts Service Registry Number, a unique identifier for substances issued by the Chemical Abstracts Service.

*1.1.12 element base_metal/**heat-lot_identification***

Type	p:string
Source	AWS A9.1, section 5.1.1.
Description	A unique identifier issued by a materials manufacturer assigned to manufacturing batches.

*1.1.13 element base_metal/**composition***

Description	Detailed chemical composition, by elements. This Type needs expansion.
Source	AWS A9.1, section 5.1.1.10

*1.1.14 element base_metal/**manufacturing_history***

Type	enumeration of p:string
Values	enumeration cold worked enumeration normalized enumeration annealed
Source	AWS A9.1, section 5.1.1.11.1
Description	Mechanical manufacturing methods used to produce the welded material.

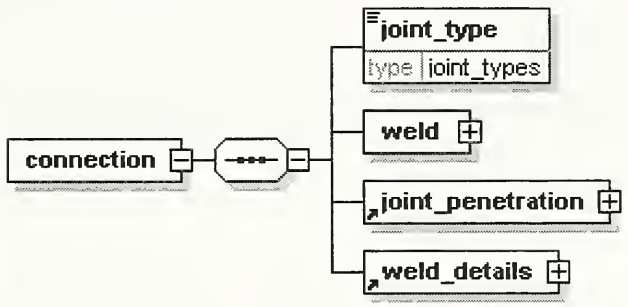
*1.1.15 element base_metal/**service_history***

Type	enumeration of p:string
Values	enumeration sour crude enumeration need expansion here
Source	AWS A9.1, section 5.1.1.11.1
Description	The mechanical forming and heat treatment methods used to produce the stock material.

*1.1.16 element base_metal/**applied_coating_specification***

Type	p:string
Source	Applies especially to AWS B4.0, section B2-9(1)
Description	Standard designation for the class of coating.

1.2 element **connection**

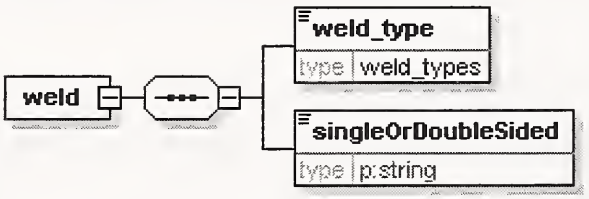
Diagram	
Children	**joint_type weld joint_penetration weld_details**
Used By	element **sub_assembly**
Source	Source: ISO 857 - section 3.1.4
Description	The joint formed by edge preparation of two workpieces and the weld that joins the workpieces together.

*1.2.1 element connection/**joint_type***

Type	**joint_types**
Values	enumeration butt_joint enumeration corner_joint enumeration t_joint

	enumeration lap_joint enumeration edge_joint enumeration flanged_butt_joint enumeration flanged_corner_joint enumeration flanged_t_joint enumeration flanged_lap_joint enumeration flanged_edge_joint
Source	AWS A3.0, Figure 1 - Joint Types and definition of term.
Description	"A weld joint classification based the relative orientation of the members being joined."

1.2.2 element ***connection/weld***

Diagram	
Children	**weld_type** **singleOrDoubleSided**
Source	AWS A3.0 definition.
Description	A region of coalescence of materials produced by heating or pressure, that joins two pieces of metal.

1.2.2.1 element connection/weld/**weld_type**

Type	**weld_types**
Values	enumeration groove enumeration fillet enumeration plug enumeration slot enumeration spot enumeration seam enumeration flange enumeration stud enumeration surfacing enumeration upset enumeration flash enumeration bevelGroove enumeration flareBevelGroove enumeration doubleBevelGroove enumeration jGroove enumeration singleJGroove enumeration uGroove enumeration singleUGroove enumeration doubleUGroove enumeration vGroove enumeration flareVGroove enumeration singleVGroove enumeration doubleVGroove enumeration squareGroove enumeration edgeFlange enumeration braze

	enumeration projection
Description	Characterization of the designed weld, by geometry of the objects being joined and of the joint.

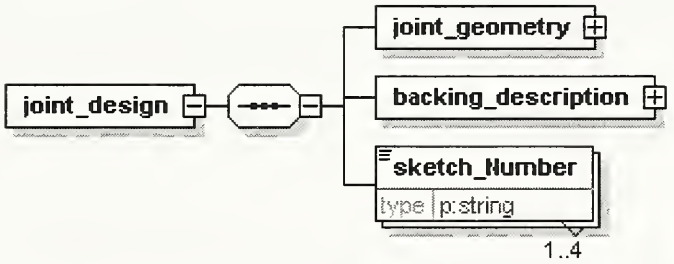
1.2.2.2 element connection/weld/**singleOrDoubleSided**

Type	enumeration of p:string
Values	enumeration single_sided enumeration two_sided
Source	See definiton of "double-welded joint", AWS A3.0, and Figures 8 and 9.
Description	Specification of welding either from only one side or both sides of the joint.

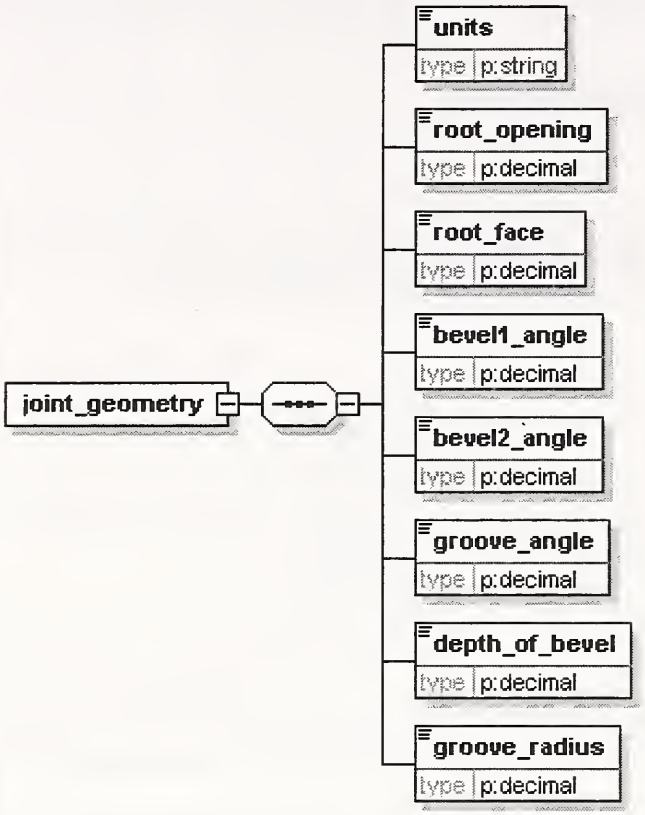
1.3 type **edge_shapes**

Type	enumeration of p:string
Values	enumeration square_edge enumeration single_bevel_edge enumeration double_bevel_edge enumeration single_j_edge enumeration double_j_edge enumeration flanged_edge enumeration round
Source	AWS 3.0, Figure 7 - Edge Shapes
Description	Shape of the edge of a single piece of base material made to form a joint with another piece of base material.

1.4 element **joint_design**

Diagram	
Children	**joint_geometry backing_description sketch_number**
Used by	elements **weld_details welding_procedure_specification**
Source	Source: AWS 2.1:2000, 2.13.1 p. 20
Description	AWS 3.0, p. 19 : "Detailed Description of mating configuration of two components, sufficient information for shop preparation of the components."

1.4.1 element joint_design/**joint_geometry**

Diagram	
Children	**units root_opening root_face bevel1_angle bevel2_angle groove_angle depth_of_bevel groove_radius**
Source	AWS 3.0 Definition, p. 19, and Figure 6, p. 45.
Description	Dimensions of joint root, bevel, and groove features.

1.4.1.1 element joint_design/joint_geometry/**units**

Type	enumeration of p:string
Values	enumeration millimeters enumeration inches
Description	Choice of SI or U.S. Customary units for the linear dimensions.

1.4.1.2 element joint_design/joint_geometry/**root_opening**

Type	p:decimal
Description	See AWS 3.0, Figure 6.

1.4.1.3 element joint_design/joint_geometry/**root_face**

Type	p:decimal
Source	See AWS A3.0 definition, and Figure 5.
Description	"That portion of the groove face within the joint root".

1.4.1.4 element joint_design/joint_geometry/**bevel1_angle**

Type	p:decimal
Description	See AWS A3.0, Figure 6. Units: degrees.

1.4.1.5 element joint_design/joint_geometry/**bevel2_angle**

Type	p:decimal
Description	See AWS A3.0, Figure 6. Units: degrees.

1.4.1.6 element joint_design/joint_geometry/**groove_angle**

Type	p:decimal
Description	See AWS A3.0, Figure 6. Units: degrees

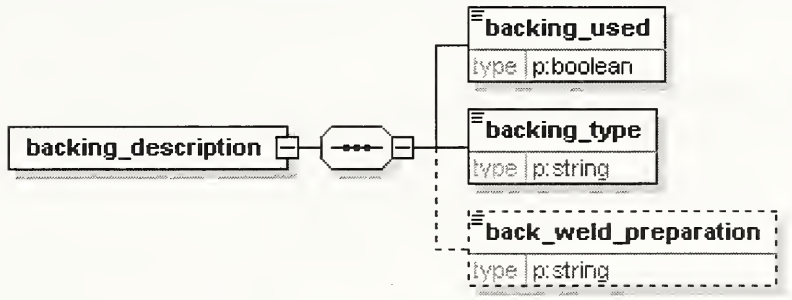
1.4.1.7 element joint_design/joint_geometry/**depth_of_bevel**

Type	p:decimal
Description	See AWS A3.0, Figure 6. Units: degrees

1.4.1.8 element joint_design/joint_geometry/**groove_radius**

Type	p:decimal
Description	See AWS A3.0, Figure 6. Units: degrees

*1.4.2 element joint_design/**backing_description***

Diagram	
Children	**backing_used backing_type back_weld_preparation**
Description	AWS A3.0: "Material placed against the back side of the joint to support and retain molten weld metal".

1.4.2.1 element joint_design/backing_description/**backing_used**

Type	p:boolean
Description	Boolean stating if backing is required for the weld.

1.4.2.2 element joint_design/backing_description/**backing_type**

Type	enumeration of p:string
Values	enumeration none enumeration strip enumeration strap enumeration ring enumeration split-pipe enumeration weld/sealing run enumeration consumable insert enumeration copper bar enumeration non metallic enumeration retaining shoes enumeration flux backing enumeration backing tape enumeration refractory material enumeration backing_not_alllowed(for PQR)
Source	Source: Welding Handbook, V2, pp. 58, 218, 274. Jefferson's Welding Encyclopedia, p. 46, ISO 9692, ISO 17659.
Description	Most backing Types do not apply to all Types of welding, and should be restricted to the appropriate welding technology (by further refining the definitions, e.g., shoes are typically slag welding only).

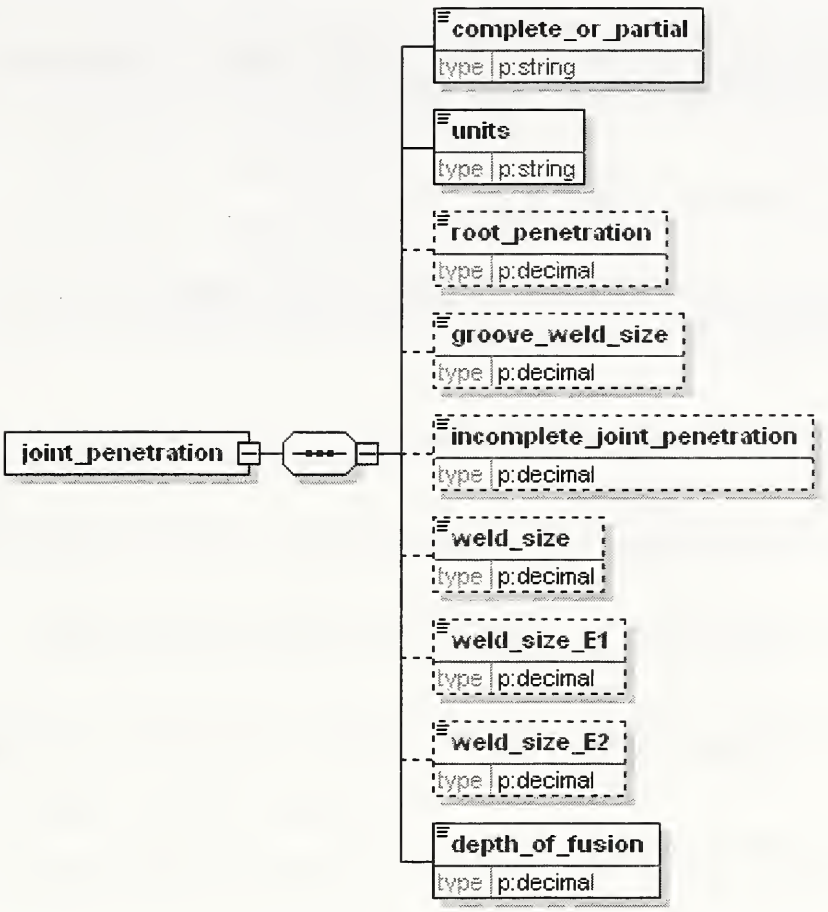
1.4.2.3 element joint_design/backing_Description/**back_weld_preparation**

Type	enumeration of p:string
Values	enumeration none enumeration gouging enumeration chipping
Description	AWS A3.0: "Removal of weld metal and base metal from the weld root side of a joint for subsequent welding from that side".

*1.4.3 element joint_design/**sketch_number***

Type	p:string
Description	Reference to a sketch of the joint design, the drawing number.

1.5 element **joint_penetration**

Diagram	
Children	**complete_or_partial units root_penetration groove_weld_size incomplete_joint_penetration weld_size weld_size_E1 weld_size_E2 depth_of_fusion**
Used By	element **connection**
Source	AWS A3.0, Figure 26 - "Joint Penetration...", Figure 30 - Fusion Welds
Description	Various dimensions of penetration of the weld into the base materials.

*1.5.1 element joint_penetration/**complete_or_partial***

Type	enumeration of p:string
Values	enumeration completePenetration enumeration partialPenetration
Description	The weld design calls for partial or complete penetration.

*1.5.2 element joint_penetration/**units***

Type	enumeration of p:string
Values	enumeration millimeters enumeration inches
Description	Selection of SI or U.S. Customary units for linear measurements.

*1.5.3 element joint_penetration/**root_penetration***

Type	p:decimal
Source	AWS A3.0, definition, and Figure 26 - "Joint Penetration...", Figure 30 - Fusion Welds
Description	"The distance the weld metal extends into the root joint".

*1.5.4 element joint_penetration/**groove_weld_size***

Type	p:decimal
Source	AWS A3.0, Figure 26 - "Joint Penetration...", Figure 30 - Fusion Welds
Description	"The joint penetration of a groove weld".

*1.5.5 element joint_penetration/**incomplete_joint_penetration***

Type	p:decimal
Description	See AWS A3.0 definition, and Figure 26 - "Joint Penetration...", Figure 30 - Fusion Welds

*1.5.6 element joint_penetration/**weld_size***

Type	p:decimal
Description	See AWS A3.0 definition and Figure 26 - "Joint Penetration...", Figure 30 - Fusion Welds

*1.5.7 element joint_penetration/**weld_size_E1***

Type	p:decimal
Description	See AWS A3.0 definition and Figure 26 - "Joint Penetration...", Figure 30 - Fusion Welds

*1.5.8 element joint_penetration/**weld_size_E2***

Type	p:decimal
Description	See AWS A3.0 definition and Figure 26 - "Joint Penetration...", Figure 30 - Fusion Welds

*1.5.9 element joint_penetration/**depth_of_fusion***

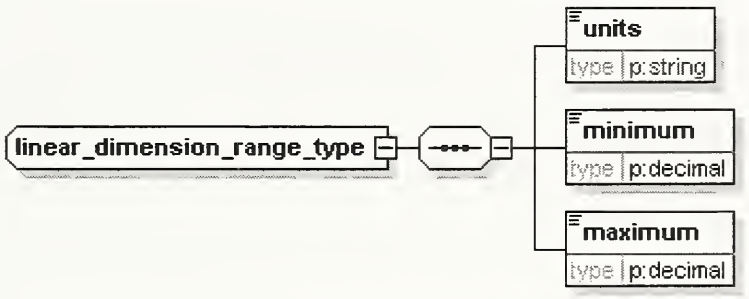
Type	p:decimal
Source	AWS 3.0 definition, and Figure 26 - "Joint Penetration...", Figure 30 - Fusion Welds
Description	"The distance that fusion extends into the base metal or the previous bead from the surface melted during welding".

1.6 type **joint_types**

Type	enumeration of p:string
Used By	element **connection/joint_type**

Values	enumeration butt_joint enumeration corner_joint enumeration t_joint enumeration lap_joint enumeration edge_joint enumeration flanged_butt_joint enumeration flanged_corner_joint enumeration flanged_t_joint enumeration flanged_lap_joint enumeration flanged_edge_joint
Source	AWS A3.0 definition and Figure 2, p. 42
Description	"A weld joint classification based on relative orientation of members being joined".

1.7 type **linear_dimension_range_type**

Diagram	
Children	**units minimum maximum**
Description	Inclusive limits on dimension of a material, e.g., thickness of base plate.

*1.7.1 element linear_dimension_range_type/**units***

Type	enumeration of p:string
values	enumeration millimeters enumeration inches enumeration gauge
Description	Choice of units to describe a linear dimension.

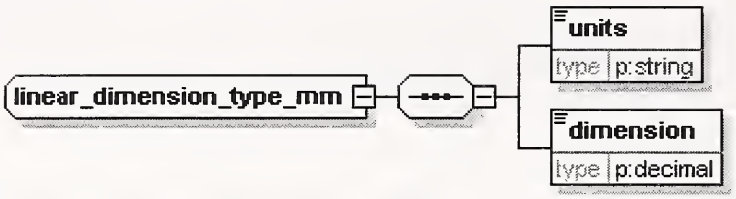
*1.7.2 element linear_dimension_range_type/**minimum***

Type	p:decimal
Description	Inclusive minimum limit.

*1.7.3 element linear_dimension_range_type/**maximum***

Type	p:decimal
Description	Inclusive maximum limit.

1.8 type **linear_dimension_type_mm**

Diagram	
Children	**units dimension**
Used by	elements **variables_specification/contact_tube_to_work_distance** **variables_specification/stickout**
Description	Specifies U.S. Customary or SI units for linear measurement of dimensions less than 500 mm. Contrast to units that would be used to measure, e.g., length of weld bead deposited per hour.

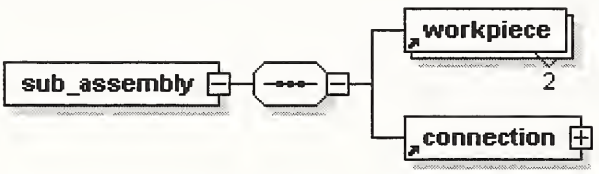
*1.8.1 element linear_dimension_type_mm/**units***

Type	enumeration of p:string
Values	enumeration millimeters enumeration inches
Description	Choice of SI or U.S. Customary units.

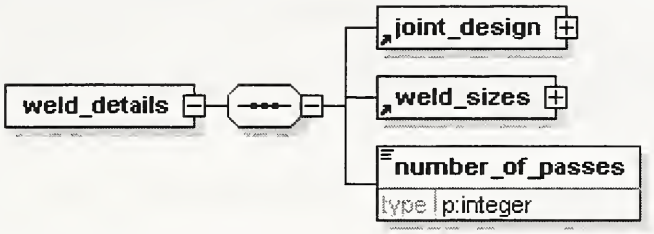
*1.8.2 element linear_dimension_type_mm/**dimension***

Type	p:decimal
Description	The scalar quantity of the measurement.

1.9 element **sub_assembly**

Diagram	
Children	**workpiece connection**
Used By	element **weldment**
Source	Welding Handbook, Vol. 1, p. 136.
Description	Two workpieces joined by a weld. Identifies simple weldments that can be joined to form a larger more complicated weldment.

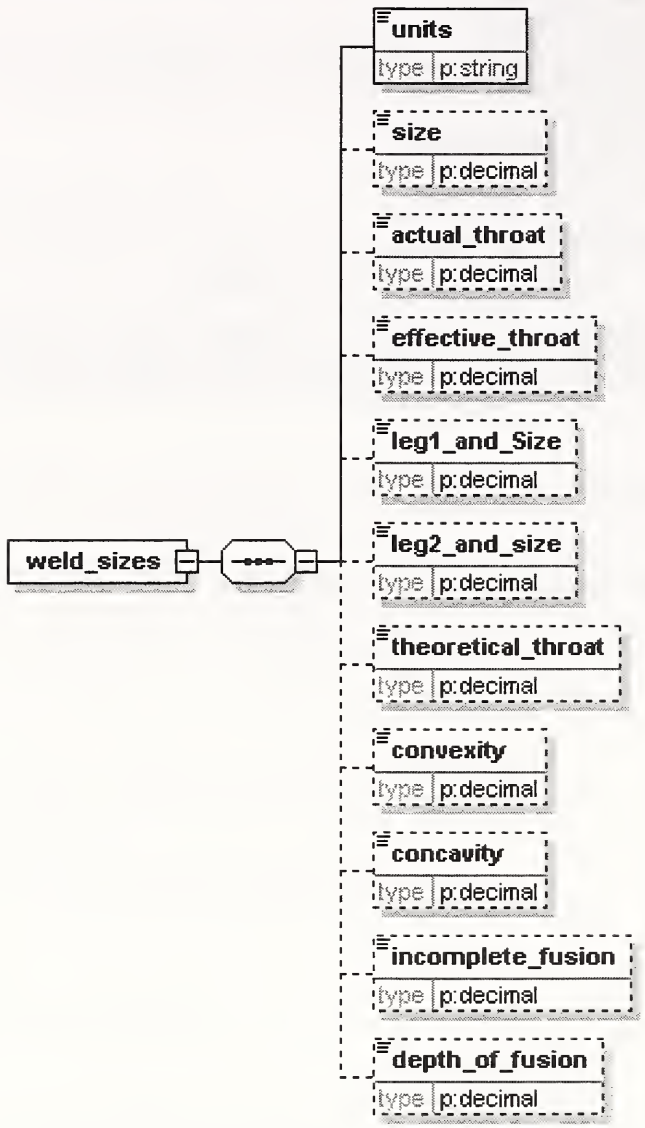
1.10 element **weld_details**

Diagram	
Children	**joint_design** **weld_sizes** **number_of_passes**
Used By	element **connection**
Source	No standards Source for this parameter. See definition of "welding variable" in AWS B2.1.
Description	Information describing the joint and the geometric parameters of the designed weld.

*1.10.1 element weld_details/**number_of_passes***

Type	p:integer
Description	Number of times needed to deposit weld metal to complete the weld.

1.11 element **weld_sizes**

Diagram	
Children	**units size actual_throat effective_throat leg1_and_size leg2_and_size theoretical_throat convexity concavity incomplete_fusion depth_of_fusion**
Used By	element **weld_details**
Source	AWS 3.0, Figure 25 - Weld Sizes.
Description	Linear dimensions of cross sectional weld features. Sizes are of design and actual features.

*1.11.1 element weld_sizes/**units***

Type	enumeration of p:string
Values	enumeration millimeters enumeration inches
Description	Choice of SI or U.S. Customary linear measurement units.

*1.11.2 element weld_sizes/**size***

Type	p:decimal
Description	Size of a single weld bead. See AWS 3.0, Figure 25 - Weld Sizes.

*1.11.3 element weld_sizes/**actual_throat***

Type	p:decimal
Description	See AWS 3.0, Figure 25 - Weld Sizes.

*1.11.4 element weld_sizes/**effective_throat***

Type	p:decimal
Description	See AWS 3.0, Figure 25 - Weld Sizes.

*1.11.5 element weld_sizes/**leg1_and_Size***

Type	p:decimal
Description	See AWS 3.0, Figure 25 - Weld Sizes.

*1.11.6 element weld_sizes/**leg2_and_size***

Type	p:decimal
Description	See AWS 3.0, Figure 25 - Weld Sizes.

*1.11.7 element weld_sizes/**theoretical_throat***

Type	p:decimal
Description	See AWS 3.0, Figure 25 - Weld Sizes.

*1.11.8 element weld_sizes/**convexity***

Type	p:decimal
Description	See AWS 3.0, Figure 25 - Weld Sizes.

*1.11.9 element weld_sizes/**concavity***

Type	p:decimal
Description	See AWS 3.0, Figure 25 - Weld Sizes.

*1.11.10 element weld_sizes/**incomplete_fusion***

Type	p:decimal
Description	See AWS 3.0, Figure 25 - Weld Sizes.

*1.11.11 element weld_sizes/**depth_of_fusion***

Type	p:decimal
Description	See AWS 3.0, Figure 25 - Weld Sizes.

1.12 element **weldment**

Children	One or more instances of **sub_assembly**
Source	AWS A3.0
Description	"An assembly whose component parts are joined by welding"

1.13 element **workpiece**

Used By	element **sub_assembly**
Description	This element describes a piece of metal, its material, geometric properties and boundaries, including its edge shape for the welded joint. A workpiece can be a single piece of plate, or a previously assembled weldment. The scope of this data is beyond this welding data dictionary. This element represents an interface with CAD applications.

1.14 type **weld_types**

Type	enumeration of p:string
Used By	element **connection/weld/weld_type**
Values	enumeration groove enumeration fillet enumeration plug enumeration slot enumeration spot enumeration seam enumeration flange enumeration stud enumeration surfacing enumeration upset enumeration flash enumeration bevelGroove enumeration flareBevelGroove enumeration doubleBevelGroove enumeration jGroove enumeration singleJGroove enumeration uGroove enumeration singleUGroove enumeration doubleUGroove

	enumeration vGroove enumeration flareVGroove enumeration singleVGroove enumeration doubleVGroove enumeration squareGroove enumeration edgeFlange enumeration braze enumeration projection
Source	AWS 3.0 - Figures 8, 9, 15, and AWS A9.1 - Table1
Description	Classification of the weld by its joint configuration.

2. Welding Process Data

2.1 type **allied_processes**

Type	enumeration of p:string
Used By	element **welding_process_type/allied_process**
Values	enumeration oxygen_cutting(OC) enumeration arc_cutting(AC) enumeration other_cutting
Source	AWS 3.0, Figure 54b – Master Chart of Allied Processes
Description	Processes, used by manufacturers that also use welding.

2.2 type **arc_welding_processes**

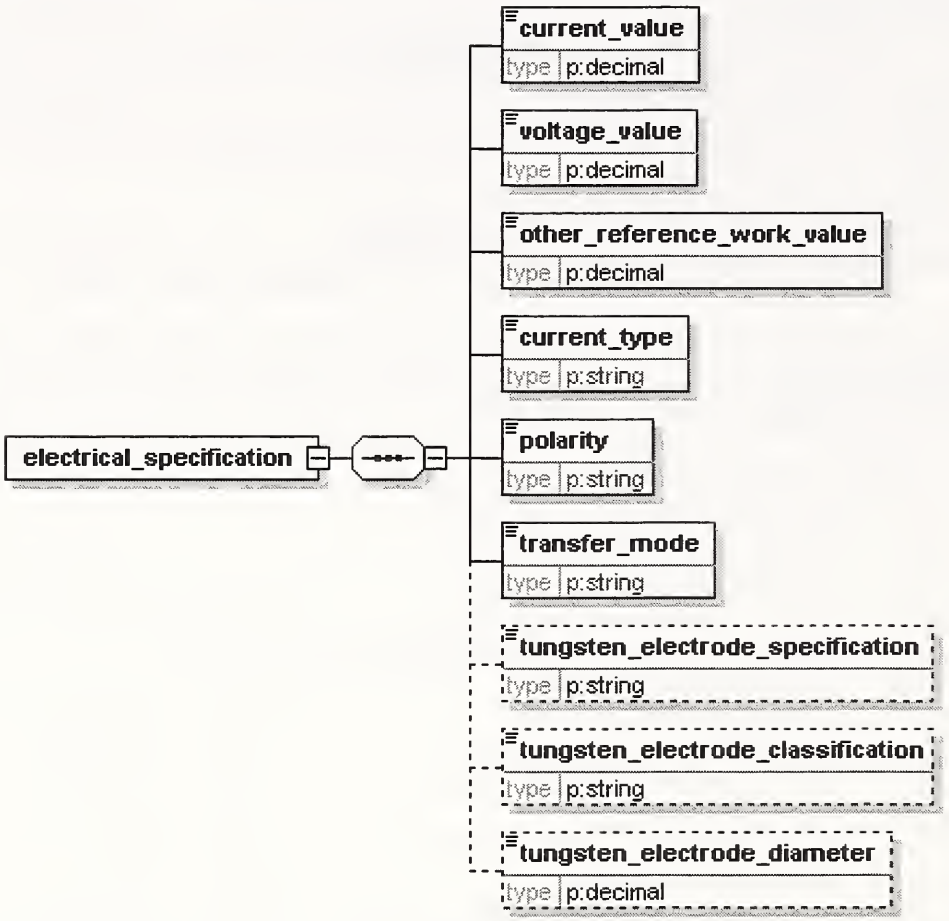
Type	enumeration of p:string
Used By	element **welding_process_type/arc_welding_process**
Values	enumeration atomicHydrogenWelding(AHW) enumeration bareMetalArcWelding(BMAW) enumeration carbonArcWelding(CAW) enumeration carbonArcWeldingGas(CAW-G) enumeration carbonArcWeldingShielded(CAW-S) enumeration electrogasWelding(EGW) enumeration electroSlagWelding(ESW) enumeration gasMetalArcWelding(GMAW) enumeration gasTungstenArcWelding(GTAW) enumeration plasmaArcWelding(PAW) enumeration shieldedMetalArcWelding(SMAW) enumeration studArcWelding(SW) enumeration submergedArcWelding(SAW) enumeration submergedArcWeldingSeries(SAW-S)
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

2.3 type **brazing_processes**

Type	enumeration of p:string
Used By	element **welding_process_type/brazing_process**
Values	enumeration block_brazing(BB) enumeration diffusion_brazing(CAB)

	enumeration dip_brazing(DB) enumeration exothermic_brazing(EXB) enumeration flow_brazing(FLOW) enumeration furnace_brazing(FB) enumeration induction_brazing(IB) enumeration infrared_brazing(IRB) enumeration resistance_brazing(RB) enumeration torch_brazing(TB) enumeration twin_carbon_arc_brazing(TCAB)
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

2.4 element **electrical_specification**

Diagram	
Children	**current_value voltage_value other_reference_work_value current_type polarity transfer_mode tungsten_electrode_specification tungsten_electrode_classification tungsten_electrode_diameter**
Used By	element **welding_procedure_specification**
Source	AWS B2.1, section 2.13.8
Description	For arc welding only, the values and types of current used.

*2.4.1 element electrical_specification/**current_value***

Type	p:decimal
Source	AWS B2.1, section 2.13.8 (1)
Description	Current used for a procedure, or current specified (units are amperes).

*2.4.2 element electrical_specification/**voltage_value***

Type	p:decimal
Source	AWS B2.1, section 2.13.8 (2)
Description	The voltage to be maintained by the power source, measured between the electrode and the workpiece. Units are volts.

*2.4.3 element electrical_specification/**other_reference_work_value***

Type	p:decimal
Description	Commanded variable level for use by various control modes, especially synergic. Units could be WFS, with current levels determined by the intelligent power source.

*2.4.4 element electrical_specification/**current_type***

Type	enumeration of p:string
Values	enumeration constant_current enumeration constant_voltage enumeration pulsed
Source	AWS B2.1, section 2.13.8 (1)
Description	The flow of current implemented by the power source.

*2.4.5 element electrical_specification/**polarity***

Type	enumeration of p:string
Values	enumeration DCEP enumeration DCEN enumeration AC enumeration PULSED
Source	AWS B2.1, section 2.13.8 (1)
Description	The electrical polarity between the electrode and the workpiece, in direct current arc welding.

*2.4.6 element electrical_specification/**transfer_mode***

Type	enumeration of p:string
Values	enumeration spray enumeration globular enumeration short circuit enumeration not applicable
Source	AWS B2.1, section 2.13.8 (5)

Description	The method for causing molten weld metal to leave the consumable electrode and enter the weld pool.

*2.4.7 element electrical_specification/**tungsten_electrode_specification***

Type	p:string
Source	AWS A9.1, section 5.1.8, and AWS A5.12.
Description	Description of the electrode's chemical composition, and length and diameter.

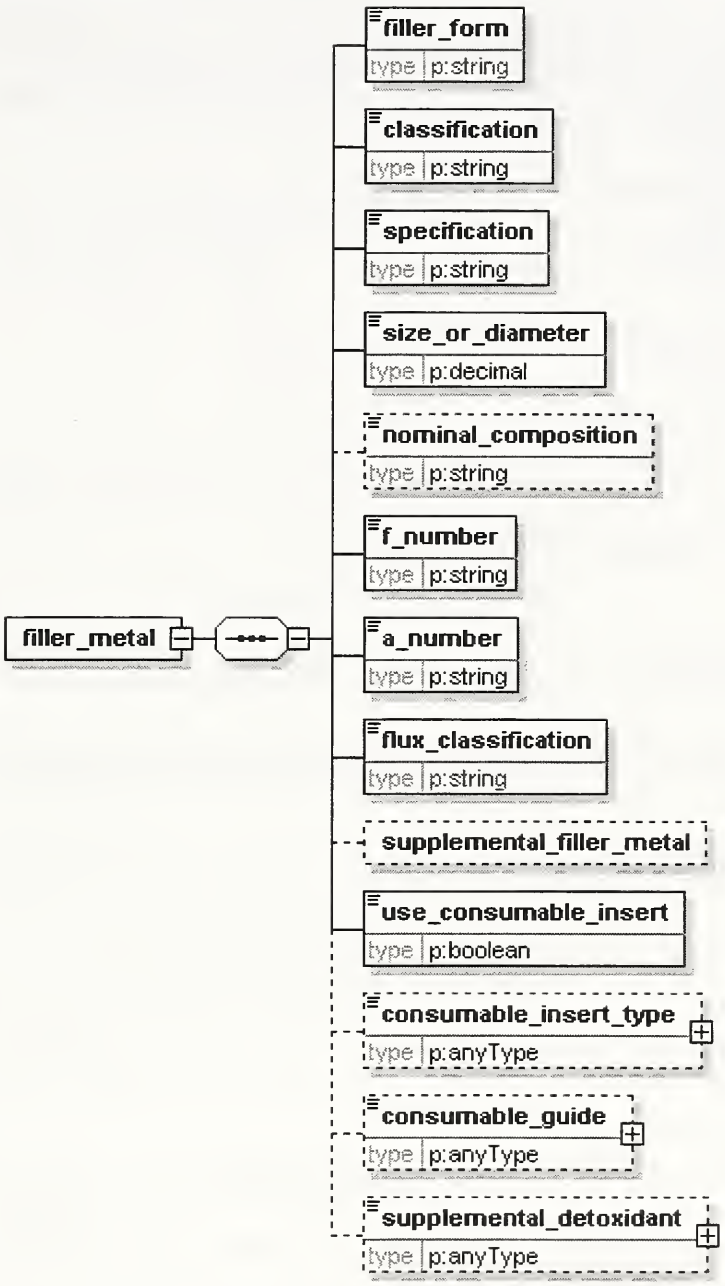
*2.4.8 element electrical_specification/**tungsten_electrode_classification***

Type	p:string
Source	AWS A9.1, section 5.1.8, and AWS A5.12.
Description	The name of a formal AWS or ISO class, determined by the chemical composition.

*2.4.9 element electrical_specification/**tungsten_electrode_diameter***

Type	linear_dimension_type_mm
Source	AWS A9.1, section 5.1.8
Description	Diameter of the electrode.

2.5 element **filler_metal**

Diagram	
Children	**filler_form classification specification size_or_diameter nominal_composition f_number a_number flux_classification supplemental_filler_metal consumable_insert consumable_insert_type consumable_guide supplemental_deoxidant**
Used By	element **welding_procedure_specification**
Source	AWS B2.1, Section 2.13.3
Description	AWS A3.0 definition: "Metal or alloy added in making a ... joint".

2.5.1 element filler_metal/***filler_form***

Type	enumeration of p:string
Values	enumeration wire enumeration wire_coiled enumeration wire_spooled enumeration round_wire enumeration rectangular_wire enumeration strip_coiled enumeration strip_spooled enumeration round_wire enumeration rod enumeration rod_rectangular enumeration rod_round enumeration powder_and_paste enumeration foil enumeration sheet
Source	AWS
Description	Physical shape of the filler metal and of its bulk configuration.

2.5.2 element filler_metal/***classification***

Type	p:string
Description	A formal AWS or ISO designation assigned according to the chemical composition.

2.5.3 element filler_metal/***specification***

Type	p:string
Description	A designation including composition and physical properties of the filler metal.

2.5.4 element filler_metal/***size_or_diameter***

Type	linear_dimension_type_mm
Description	Diameter of round metal, or dimensions of prismatic shaped metal.

2.5.5 element filler_metal/***nominal_composition***

Type	p:string
Description	Use only if a formal classification is not used.

2.5.6 element filler_metal/***f_number***

Type	p:string
Description	AWS B2.1 definiton: "A designation used to group welding filler metal for procedure and performance qualifications".

2.5.7 *element filler_metal/**a_number***

Type	p:string
Description	AWS B2.1 definition: "a designation to classify ferrous weld metal for procedure qualification based upon chemical composition".

2.5.8 *element filler_metal/**flux_classification***

Type	enumeration of p:string
Values	enumeration none enumeration solid/metal core enumeration flux_cored enumeration powder_cored
Description	The formal classification of the flux. e.g., ANSI/AWS A5.20 describes classes for carbon steel electrodes for flux cored arc welding.

2.5.9 *element filler_metal/**supplemental_filler_metal***

Type	p:string
Description	Specification of a filler metal used in addition to a consumable electrode.

2.5.10 *element filler_metal/**use_consumable_insert***

Type	p:boolean
Description	Boolean stating whether a consumable insert is required or specified.

2.5.11 *element filler_metal/**consumable_insert_type***

Type	p:string
Description	Specification of the material property and its size.

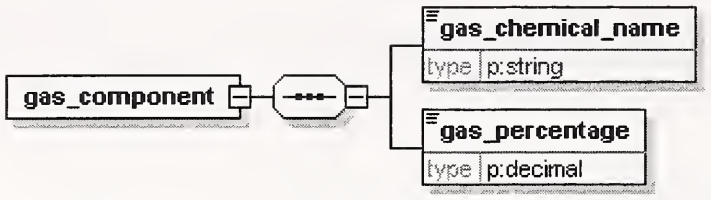
2.5.12 *element filler_metal/**consumable_guide***

Type	p:string
Description	Material used to contain the weld pool that is melted and becomes part of the weld.

2.5.13 *element filler_metal/**supplemental_deoxidant***

Type	p:string
Description	Material added to reduce formation of compounds of oxygen during welding.

2.6 element **gas_component**

Diagram	
Children	**gas_chemical_name** **gas_percentage**
Used By	type **shielding_gas_type**
Source	ANSI/AWS A9.1, section 5.1.7
Description	A single gas element of a mixture and its percentage of the mixture by weight.

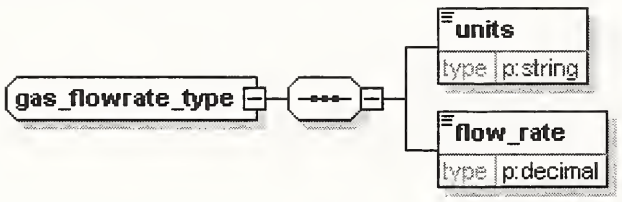
*2.6.1 element gas_component/**gas_chemical_name***

Type	enumeration of p:string
Values	enumeration **argon** enumeration **carbon dioxide** enumeration **helium** enumeration **hydrogen** enumeration **oxygen**
Description	Name of a single element or compound of gas.

*2.6.2 element gas_component/**gas_percentage***

Type	p:decimal
Description	Percentage by weight this gas occupies of the total gas mixture.

2.7 type **gas_flowrate_type**

Diagram	
Children	**units** **flow_rate**
Used By	elements **shielding_gas_for_procedure/backing_gas_flowrate** **shielding_gas_for_procedure/torch_shielding_gas_flowrate** **shielding_gas_for_procedure/trailing_shielding_gas_flowrate**
Description	Flow rate in either U.S. Customary or SI units.

*2.7.1 element gas_flowrate_type/**units***

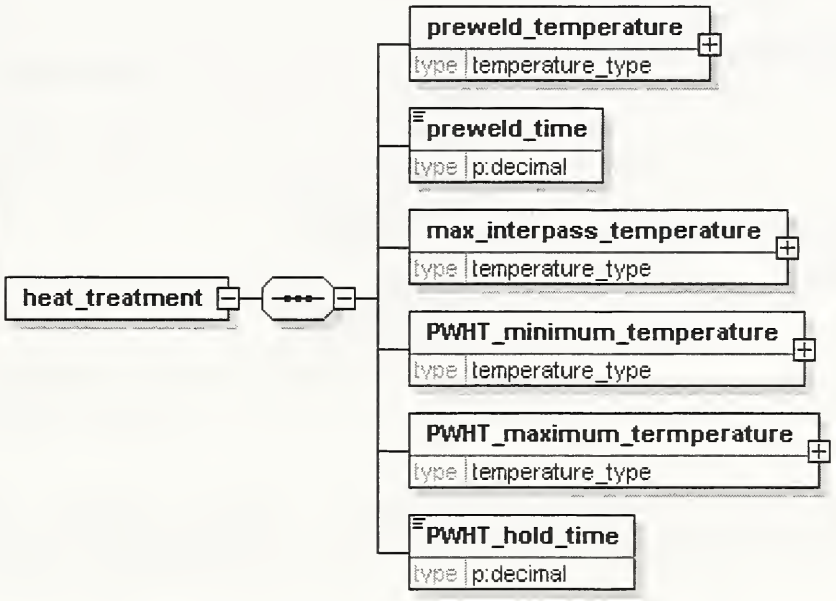
Type	enumeration of p:string

Values	enumeration liters per minute enumeration cubic feet per hour

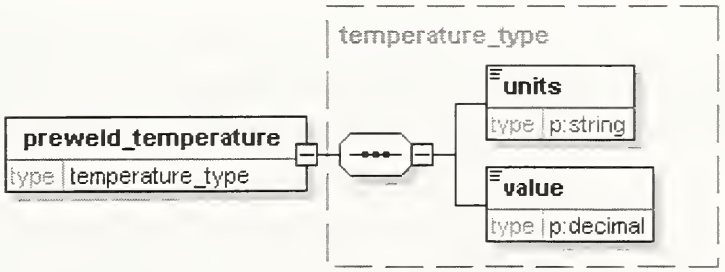
*2.7.2 element gas_flowrate_type/**flow_rate***

Type	p:decimal

2.8 element **heat_treatment**

Diagram	
Children	**preweld_temperature** **preweld_time** **max_interpass_temperature** **PWHT_minimum_temperature** **PWHT_maximum_termperature** **PWHT_hold_time**
Used By	element **welding_procedure_specification**
Source	AWS B2.1, section 2.13.6. Discussion of preheat in Welding Handbook, V2, pp. 206, 253-255
Description	Description of the heating of a joint (if required) before or after welding, or of maximum or minimum required temperatures to be maintained during welding to improve or maintain desireable properties of the base metal or of the weld.

*2.8.1 element heat_treatment/**preweld_temperature***

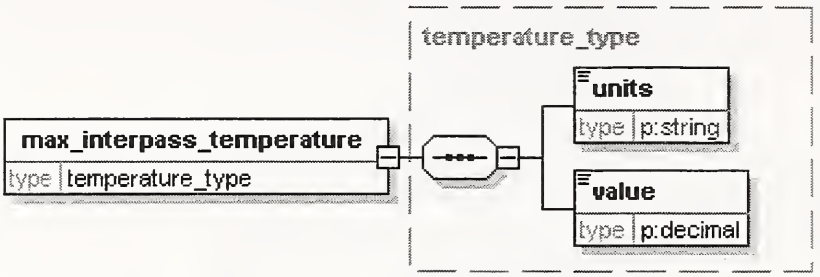
Diagram	
Type	**temperature_type**
Children	**units** **value**

Source	AWB B2.1, section 2.13.5 (1).
Description	Required temperature of base material before welding begins.

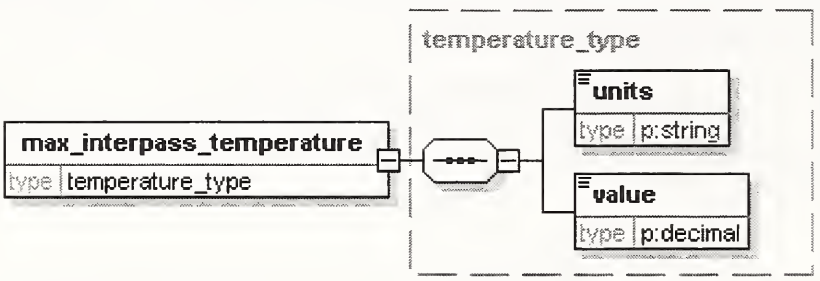
*2.8.2 element heat_treatment/**preweld_time***

Type	p:decimal
Source	AWS B2.1, section 2.13.5 (3).
Description	Time base materials must be held at the required temperature. Need details on preferred units, e.g., whole minutes, decimal minutes, minutes + seconds.

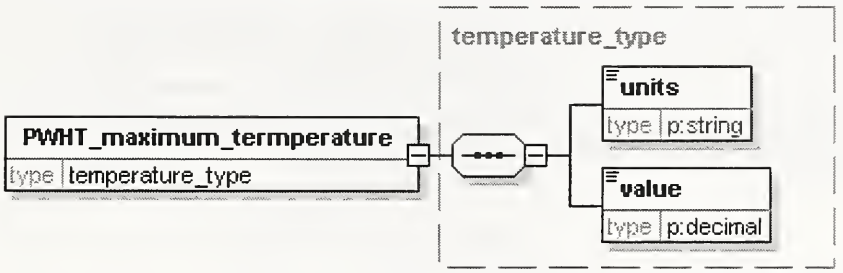
*2.8.3 element heat_treatment/**max_interpass_temperature***

Diagram	
Type	**temperature_type**
Children	**units** **value**
Source	AWS B2.1, section 2.13.5 (2), and AWS A3.0 definition.
Description	The maximum allowed temperature of the weld area between weld passes of a multipass weld.

*2.8.4 element heat_treatment/**PWHT_minimum_temperature***

Diagram	
Type	**temperature_type**
Children	**units** **value**
Description	Minimum temperature that must be maintained during heat treatment.

*2.8.5 element heat_treatment/**PWHT_maximum_termperature***

Diagram	
Type	**temperature_type**
Children	**units** **value**
Description	Maximum allowed temperature during heat treatment.

*2.8.6 element heat_treatment/**PWHT_hold_time***

Type	p:decimal
Source	AWS B2.1, section 2.13.6 (1).
Description	Units: minutes

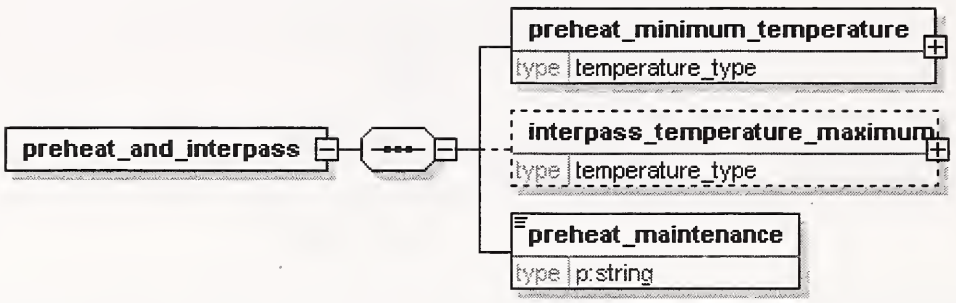
2.9 type **other_welding_processes**

Type	enumeration of p:string
Used By	element **welding_process_type/other_welding_process**
Values	enumeration electron_beam_welding(EBW) enumeration electroslag_welding(ESW) enumeration flow_welding(FLOW) enumeration induction_welding(IW) enumeration laser_beam_welding(LBW) enumeration percussion_welding(PEW) enumeration thermite_welding(TW)
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

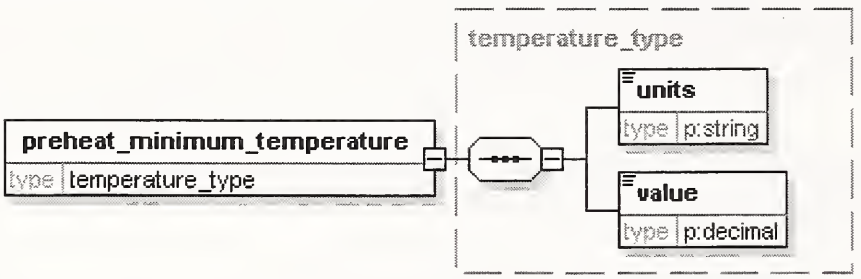
2.10 type **oxyfuel_gas_welding_processes**

Type	enumeration of p:string
Used By	element **welding_process_type/oxyfuel_gas_welding_process**
Values	enumeration air_acetylene_welding(AAW) enumeration oxyacetylene_welding(OAW) enumeration oxyhydrogen_welding(OHW) enumeration pressure_gas_welding(PGW)
Description	See AWS A3.0, Figure 54A - Master Chart of Welding and Allied Processes

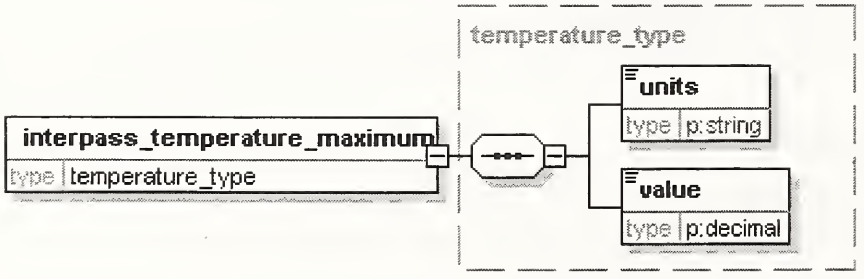
2.11 element **preheat_and_interpass**

Diagram	
Children	**preheat_minimum_temperature** **interpass_temperature_maximum** **preheat_maintenance**
Source	AWS B2.1, section 2.13.5
Description	Requirement for temperature of the base metal in the welding area immediately before welding, and requirement between weld passes.

*2.11.1 element preheat_and_interpass/**preheat_minimum_temperature***

Diagram	
Type	**temperature_type**
Children	**units** **value**
Description	Lowest allowed temperature immediately before welding.

*2.11.2 element preheat_and_interpass/**interpass_temperature_maximum***

Diagram	
Type	**temperature_type**
Children	**units** **value**
Description	Highest allowed temperature between welding passes, before another pass may be made.

*2.11.3 element preheat_and_interpass/**preheat_maintenance***

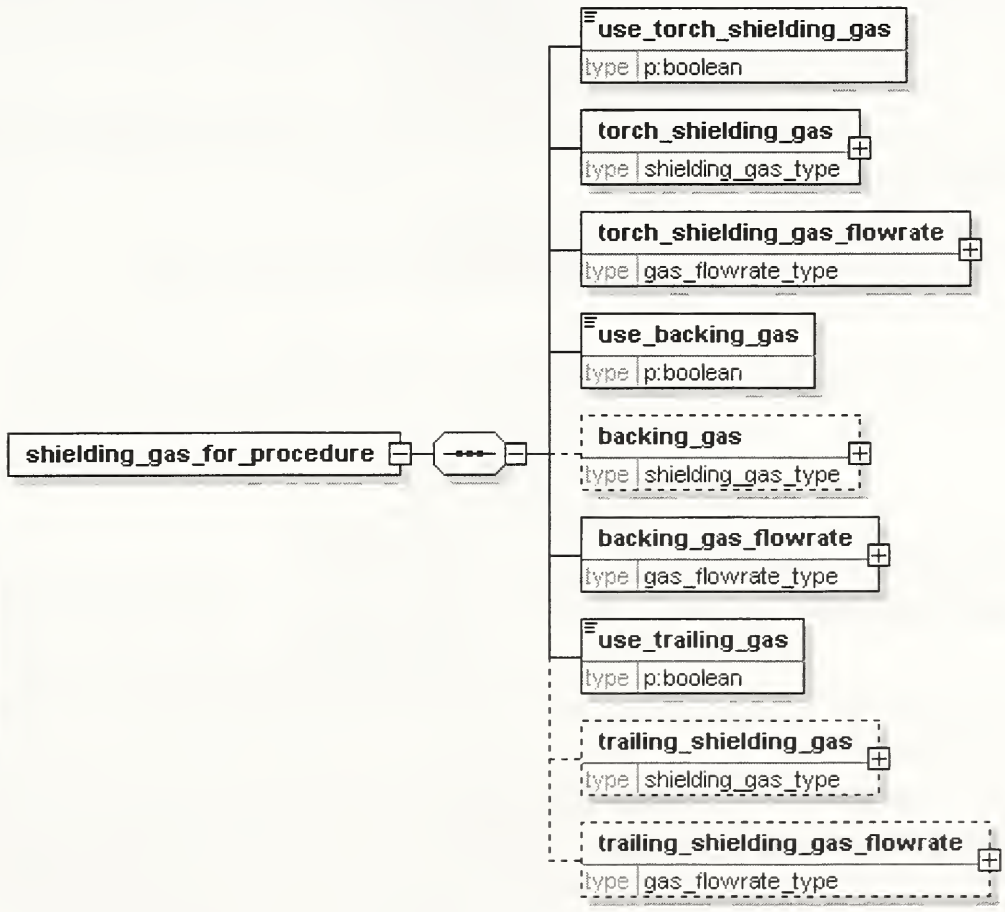
Type	enumeration of p:string
Values	enumeration continuous enumeration special heating not required
Description	Method of applying heat to insure weldment stays above minimum allowed temperature.

2.12 type **resistance_welding_processes**

Type	enumeration of p:string
Used By	element **welding_process_type/resistance_welding_process**
Values	enumeration flash_welding(FW) enumeration projection_welding(PW) enumeration resistance_spot_welding(RSW) enumeration resistance_weam_welding(RSEW) enumeration upset_welding(UW)
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

2.13 element **shielding_gas_for_procedure**

Diagram

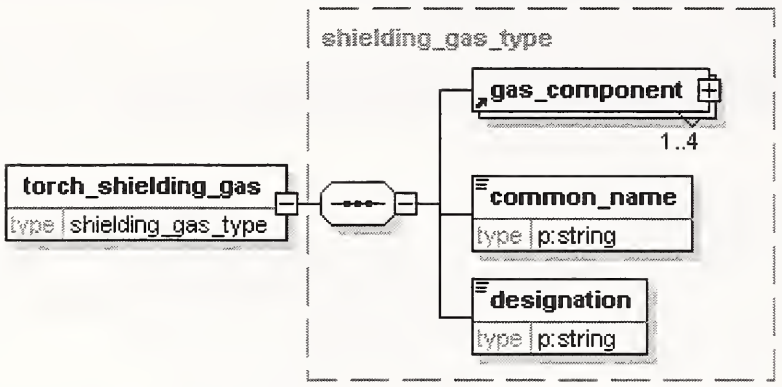


Children	**use_torch_shielding_gas torch_shielding_gas torch_shielding_gas_flowrate use_backing_gas backing_gas backing_gas_flowrate use_trailing_gas trailing_shielding_gas trailing_shielding_gas_flowrate**
Used By	element **welding_procedure_specification**
Source	AWS B2.1, section 2.13.7
Description	Description of applicable gas composition and flowrates, including torch gas shielding, backing gas, and trailing gas.

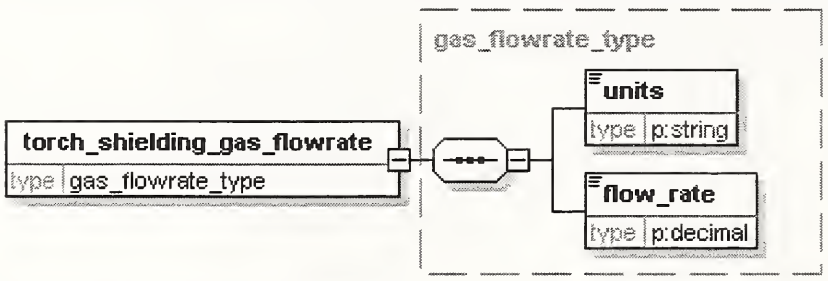
*2.13.1 element shielding_gas_for_procedure/**use_torch_shielding_gas***

Type	p:boolean
Description	Torch shielding gas is/is not required or specified.

*2.13.2 element shielding_gas_for_procedure/**torch_shielding_gas***

Diagram	
Type	**shielding_gas_type**
Children	**gas_component common_name designation**
Description	Composition of shielding gas expelled from a nozzle in the welding torch.

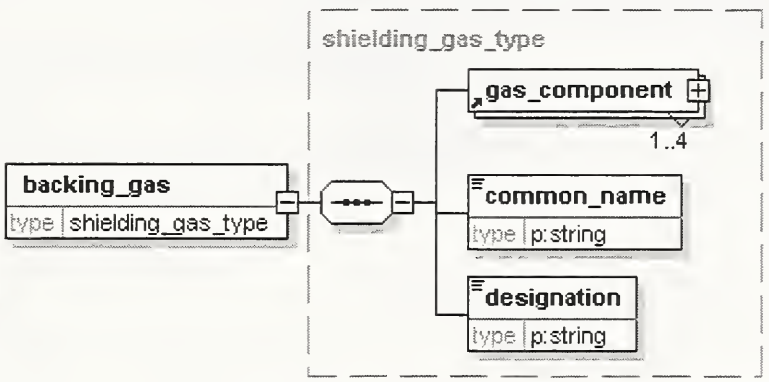
*2.13.3 element shielding_gas_for_procedure/**torch_shielding_gas_flowrate***

Diagram	
Type	**gas_flowrate_type**
Children	**units flow_rate**
Description	Flow rate of shielding gas required or specified.

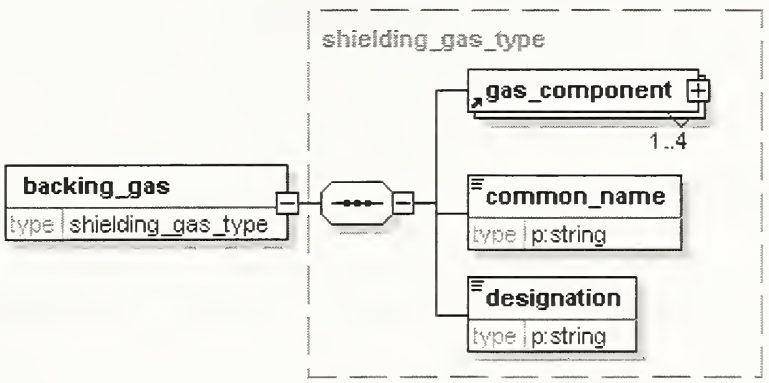
*2.13.4 element shielding_gas_for_procedure/**use_backing_gas***

Type	p:boolean
Description	Backing gas is/is not required or specified.

*2.13.5 element shielding_gas_for_procedure/**backing_gas***

Diagram	
Type	**shielding_gas_type**
Children	**gas_component common_name designation**
Description	Specification of the component gases of the mixture.

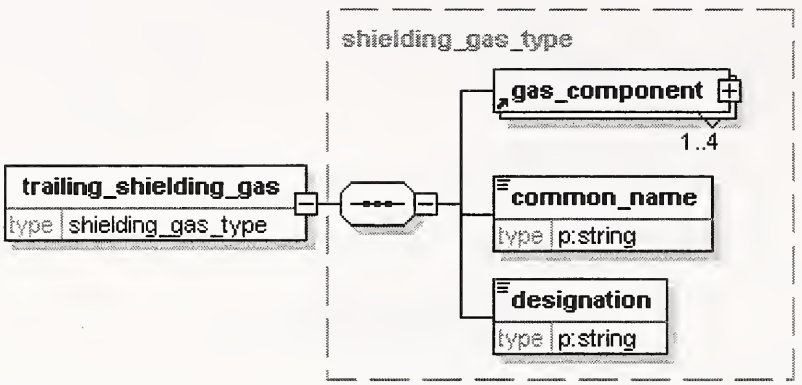
*2.13.6 element shielding_gas_for_procedure/**backing_gas_flowrate***

Diagram	
Type	**gas_flowrate_type**
Children	**units flow_rate**
Description	Flowrate of backing gas.

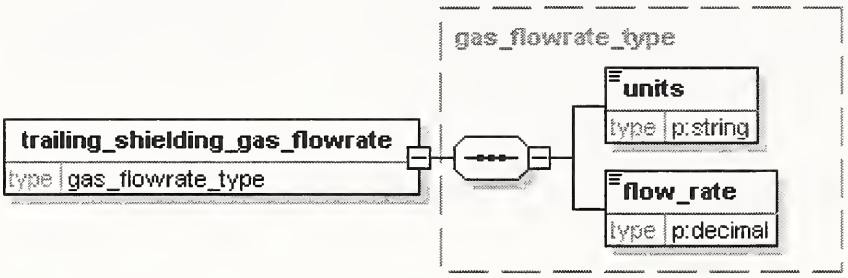
*2.13.7 element shielding_gas_for_procedure/**use_trailing_gas***

Type	p:boolean
Description	Trailing shielding gas is/is not required or specified.

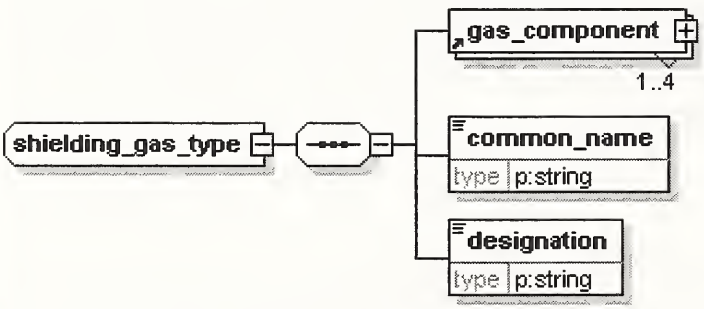
*2.13.8 element shielding_gas_for_procedure/**trailing_shielding_gas***

Diagram	
Type	**shielding_gas_type**
Children	**gas_component common_name designation**
Description	Composition or identification of trailing gas.

*2.13.9 element shielding_gas_for_procedure/**trailing_shielding_gas_flowrate***

Diagram	
Type	**gas_flowrate_type**
Children	**units flow_rate**
Description	Flowrate of trailing gas during welding.

2.14 type **shielding_gas_type**

Diagram	
Children	**gas_component common_name designation**
Used By	elements **shielding_gas_for_procedure/backing_gas**

	shielding_gas_for_procedure/torch_shielding_gas **shielding_gas_for_procedure/trailing_shielding_gas**
Description	Description of a gas or gas mixture used for shielding in arc welding.

*2.14.1 element shielding_gas_type/**common_name***

Type	p:string
Description	Trade name for the gas mixture.

*2.14.2 element shielding_gas_type/**designation***

Type	p:string
Description	Specification according to AWS classification by chemical composition of the gas mixture.

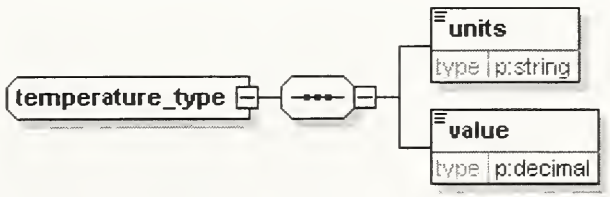
2.15 type **soldering_processes**

Type	p:string
Used By	element **welding_process_type/soldering_process**
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

2.16 type **solid_state_welding_processes**

Type	enumeration of p:string
Used By	element **welding_process_type/solid_state_welding_process**
Values	enumeration coextrusion_welding(CEW) enumeration cold_welding(CW) enumeration diffusion_welding(DFW) enumeration explosion_welding(EXW) enumeration forge_welding(FOW) enumeration friction_welding(FRW) enumeration hot_pressure_welding(HPW) enumeration ultrasonic_welding(USW)
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

2.17 type **temperature_type**

Diagram	
Children	**units** **value**
Used By	elements **preheat_and_interpass/interpass_temperature_maximum** **heat_treatment/max_interpass_temperature**

	preheat_and_interpass/preheat_minimum_temperature **heat_treatment/preweld_temperature** **heat_treatment/PWHT_maximum_termperature** **heat_treatment/PWHT_minimum_temperature**
Description	Specifies temperature units and the value.

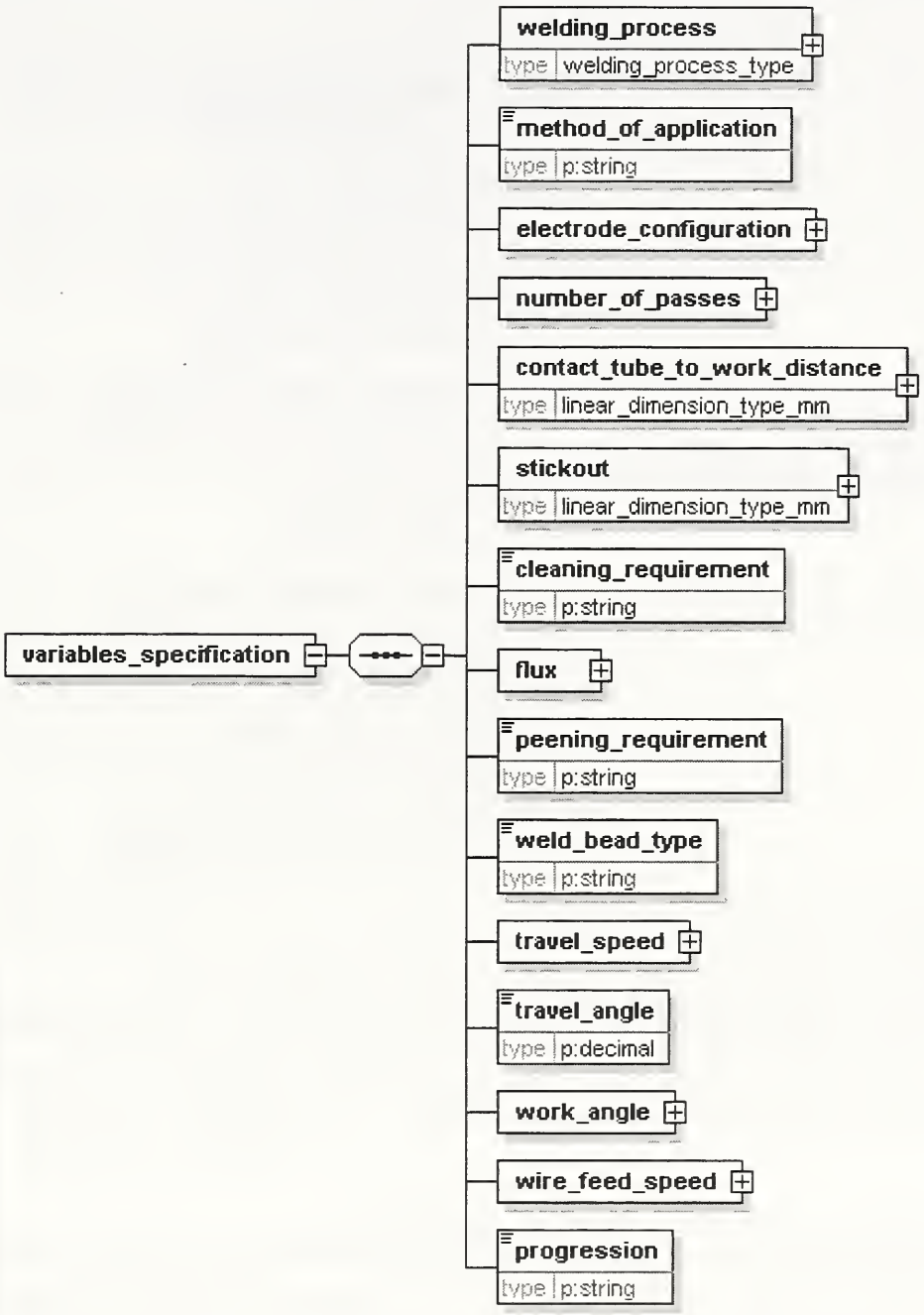
*2.17.1 element temperature_type/**units***

Type	enumeration of p:string
Values	enumeration fahrenheit enumeration centigrade
Description	Choice of U.S. Customary or SI units.

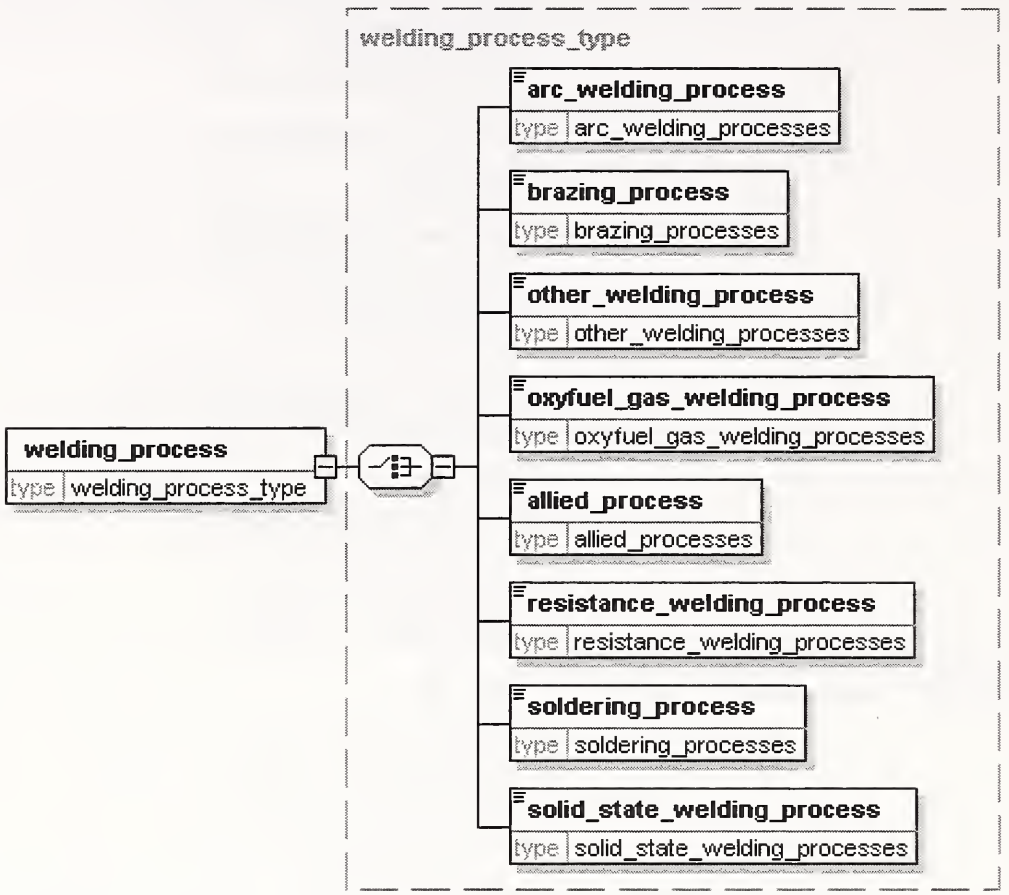
*2.17.2 element temperature_type/**value***

Type	p:decimal
Description	Numeric value.

2.18 element **variables_specification**

Diagram	
Children	welding_process method_of_application electrode_configuration number_of_passes contact_tube_to_work_distance stickout cleaning_requirement flux peening_requirement weld_bead_type travel_speed travel_angle work_angle wire_feed_speed progression
Used By	element **welding_procedure_specification**
Source	AWS B2.1, section 2.13.9
Description	Detailed information in a WPS that supplements the basic parameters.

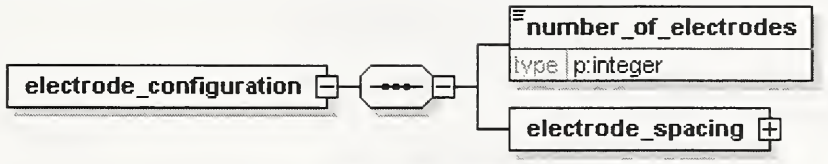
2.18.1 element variables_specification/**welding_process**

Diagram	
Type	**welding_process_type**
Children	**arc_welding_process brazing_process other_welding_process oxyfuel_gas_welding_process allied_process resistance_welding_process soldering_process solid_state_welding_process**
Source	AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes
Description	The standard classification of the welding process.

2.18.2 element variables_specification/***method_of_application***

Type	enumeration of p:string
Values	enumeration manual enumeration semiautomatic enumeration mechanized enumeration automatic
Source	AWS B2.1, section 2.13.9
Description	The means of manipulating the welding electrode, either by person or machine.

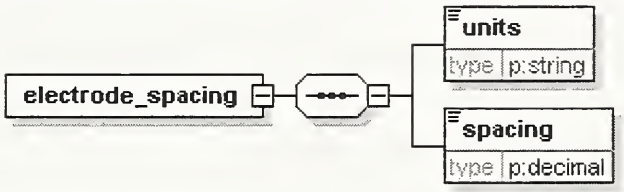
*2.18.3 element variables_specification/**electrode_configuration***

Diagram	
Children	**number_of_electrodes** **electrode_spacing**
Source	AWS B2.1, section 2.13.9(2)
Description	For non-manual welding, use of single or multiple electrodes

2.18.3.1 element variables_specification/electrode_configuration/**number_of_electrodes**

Type	p:integer
Description	Number of electrodes that conduct welding current simultaneously.

2.18.3.2 element variables_specification/electrode_configuration/**electrode_spacing**

Diagram	
Children	**units** **spacing**
Description	Distance between electrodes at point of entry to the weld pool, measured from center to center.

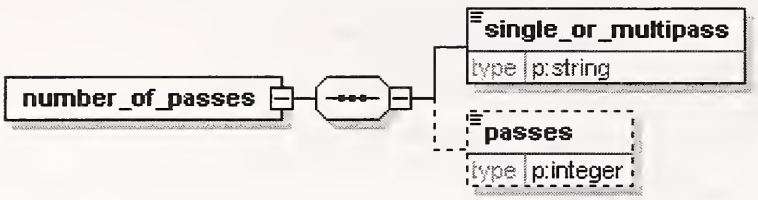
2.18.3.2.1 element variables_specification/electrode_configuration/electrode_spacing/**units**

Type	enumeration of p:string
Values	enumeration millimeters enumeration inches

2.18.3.2.2 element variables_specification/electrode_configuration/electrode_spacing/**spacing**

Type	linear_dimension_type_mm
Description	Distance from center to center between dual electrodes.

*2.18.4 element variables_specification/**number_of_passes***

Diagram	
Children	**single_or_multipass passes**
Description	Number of times a weld bead is laid down in a joint.

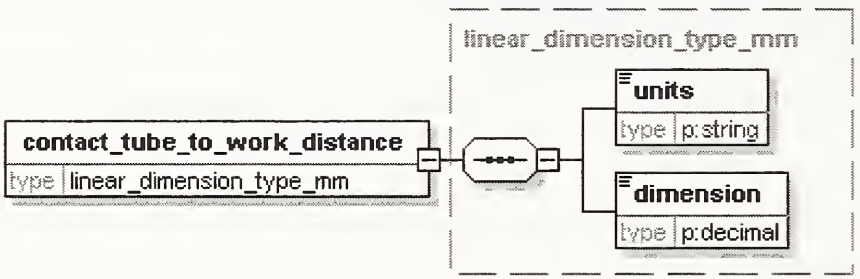
2.18.4.1 element variables_specification/number_of_passes/**single_or_multipass**

Type	enumeration of p:string
Values	enumeration single_pass enumeration multi_pass

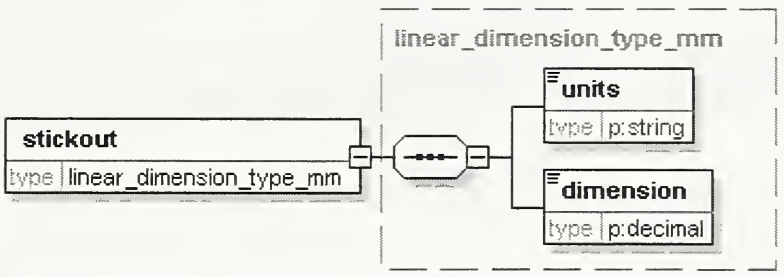
*2.18.4.2 element variables_specification/number_of_passes/**passes***

Type	p:integer

*2.18.5 element variables_specification/**contact_tube_to_work_distance***

Diagram	
Type	**linear_dimension_type_mm**
Children	**units dimension**
Source	AWS A3.0, Figure 38.
Description	In gas metal arc welding, the distance from the end of the contact tube to the metal being joined.

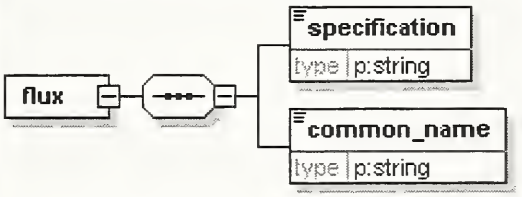
*2.18.6 element variables_specification/**stickout***

Diagram	
Type	**linear_dimension_type_mm**
Children	**units dimension**
Source	AWS A3.0 definition, and Figure 38 - GMAW Gun Nomenclature.
Description	"The length of electrode extending beyond the end of the gas nozzle."

*2.18.7 element variables_specification/**cleaning_requirement***

Type	p:string
Source	AWS B2.1, section 2.13.9 (5)
Description	Required method of cleaning before welding, done to ensure weld quality.

*2.18.8 element variables_specification/**flux***

Diagram	
Children	**specification common_name**
Source	AWS A9.1, section 5.1.5
Description	Specification of the flux required or used.

2.18.8.1 element variables_specification/flux/**specification**

Type	p:string
Description	AWS or ISO designation for the flux composition.

2.18.8.2 element variables_specification/flux/**common_name**

Type	p:string

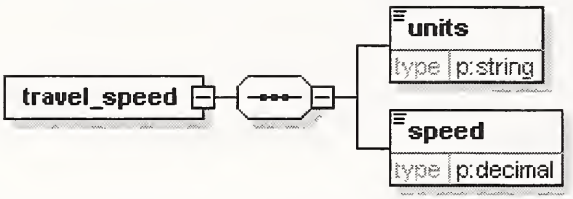
*2.18.9 element variables_specification/**peening_requirement***

Type	p:string
Source	AWS B2.1, section 2.13.9 (6).
Description	Statement of type of hammered working of the completed weld metal needed, if any.

*2.18.10 element variables_specification/**weld_bead_type***

Type	enumeration of p:string
Values	enumeration stringer bead enumeration weave bead
Source	AWS A3.0 - Figure 22, AWS B2.1, section 2.13.9
Description	A bead produced by straight line motion or oscillation of the torch.

*2.18.11 element variables_specification/**travel_speed***

Diagram	
Children	**units speed**
Source	AWS B2.1, section 2.13.9
Description	Speed of the torch during welding.

2.18.11.1 element variables_specification/travel_speed/**units**

Type	enumeration of p:string
Values	enumeration inches per minute enumeration millimeters per minute
Description	Choice of U.S. Customary or SI units.

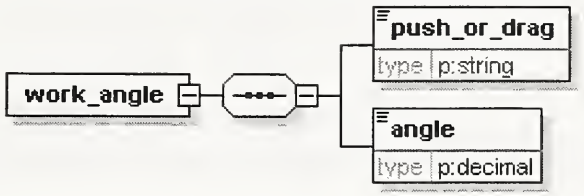
2.18.11.2 element variables_specification/travel_speed/**speed**

Type	p:decimal
Description	Linear velocity of the torch in relation to the workpiece.

*2.18.12 element variables_specification/**travel_angle***

Type	p:decimal
Source	AWS A9.1, section 5.2.5.9
Description	AWS A3.0 definition: "The angle between the electrode axis and a line perpendicular to the weld axis".

*2.18.13 element variables_specification/**work_angle***

Diagram	
Children	**push_or_drag** **angle**
Source	AWS A9.1, section 5.2.5.9.
Description	AWS A3.0 definition: "The angle between a line perpendicular to the major workpiece surface and a plane determined by the electrode axis and the weld axis"

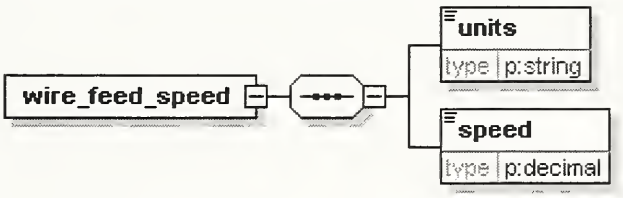
2.18.13.1 element variables_specification/work_angle/**push_or_drag**

Type	enumeration of p:string
Values	enumeration push enumeration drag

2.18.13.2 element variables_specification/work_angle/**angle**

Type	p:decimal

*2.18.14 element variables_specification/**wire_feed_speed***

Diagram	
Children	**units** **speed**
Source	Welding Handbook, V2, p. 116 "GMAW Process Variables".
Description	ANSI/AWS A3.0 definition: "The rate at which wire is consumed.."

2.18.14.1 element variables_specification/wire_feed_speed/**units**

Type	enumeration of p:string
Values	enumeration millimeters per second enumeration inches per minute

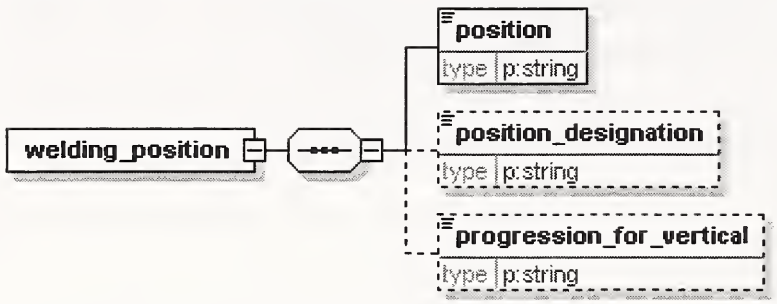
2.18.14.2 element variables_specification/wire_feed_speed/**speed**

Type	p:decimal

*2.18.15 element variables_specification/**progression***

Type	enumeration of p:string
Values	enumeration upward enumeration downward
Source	AWS B2.1, section 2.13.4 (2)
Description	The movement of the torch, or the orientation of the weld joint, in relation to the direction of gravity.

2.19 element **welding_position**

Diagram	
Children	**position position_designation progression_for_vertical**
Source	AWS B2.1, section 2.13.4, and AWS A3.0 Figures 16-20.
Description	AWS A3.0 definition: "The relationship between the weld pool, joint, joint members, and welding heat Source during welding."

*2.19.1 element welding_position/**position***

Type	enumeration of p:string
Values	enumeration flat enumeration horizontal enumeration vertical enumeration overhead enumeration all_positions(for PQRs)
Description	Name of the position.

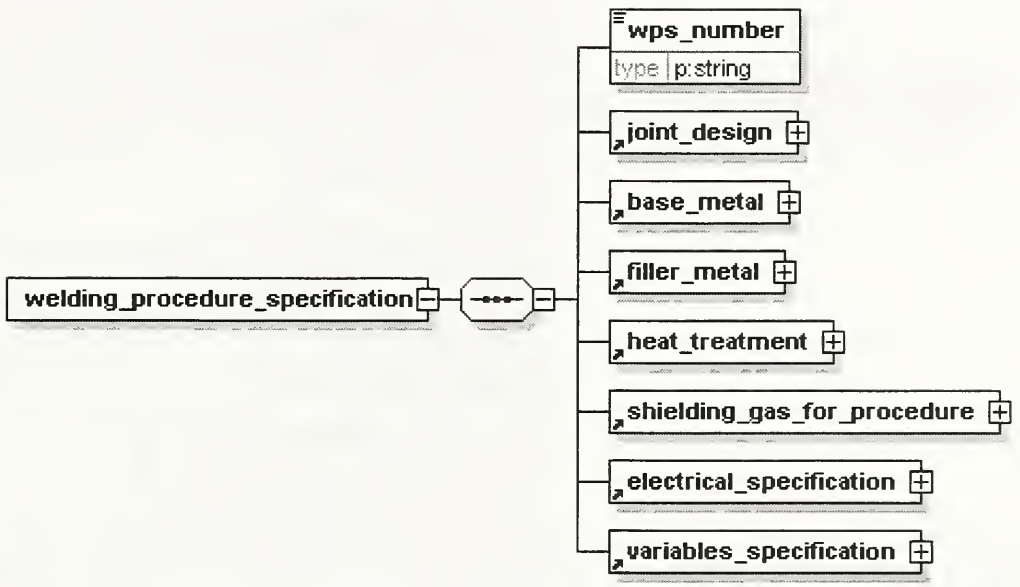
*2.19.2 element welding_position/**position_designation***

Type	enumeration of p:string
Values	enumeration 1F enumeration 1G enumeration 2F enumeration 2G enumeration 4F enumeration 4G enumeration 5F enumeration 5G
Source	AWS A3.0, Figures 16-20.
Description	The two-character abbreviation for the position.

*2.19.3 element welding_position/**progression_for_vertical***

Type	enumeration of p:string
Values	enumeration uphill enumeration downhill
Source	AWS B2.1, section 2.13.4 (2).
Description	Direction of torch travel on a weld that is inclined away from the horizontal position.

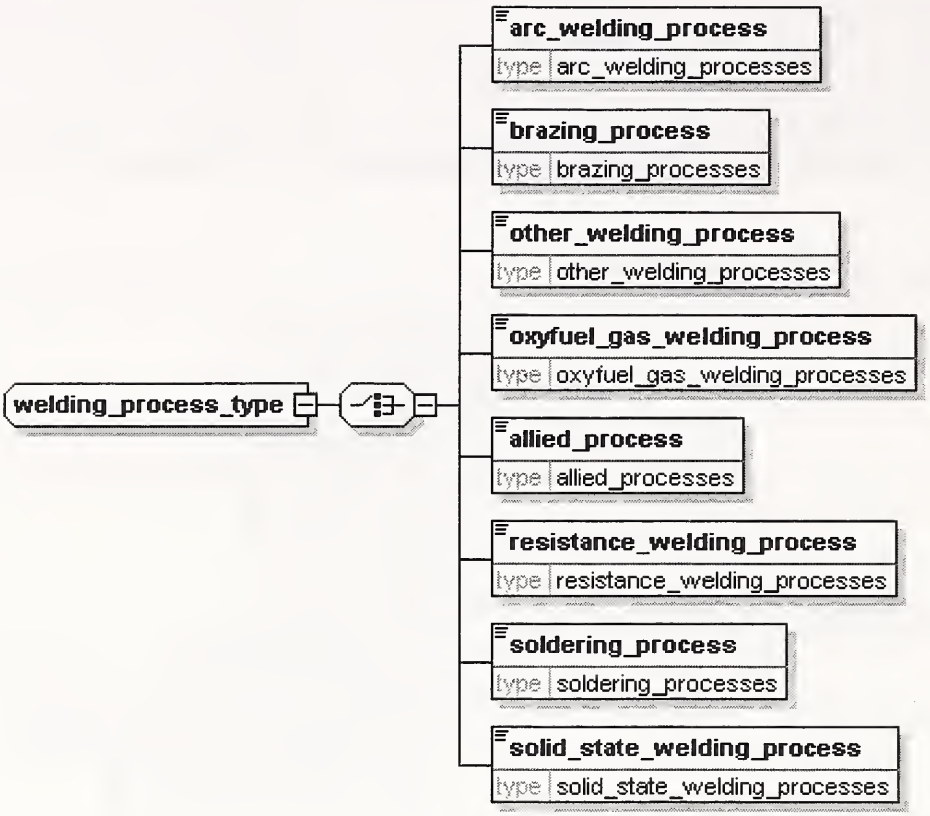
2.20 element **welding_procedure_specification**

Diagram	
Children	**wps_number joint_design base_metal filler_metal heat_treatment shielding_gas_for_procedure electrical_specification variables_specification**
Source	AWS B2.1, section 2.13.
Description	AWS A3.0 definition: "A document providing the required welding variables for a specific application..."

*2.20.1 element welding_procedure_specification/**wps_number***

Type	p:string
Source	Use of WPS number appears in many suggested report forms, including AASHTO/AWS D1.5M:D1.5/2002, Form III-2, and AWS B4.0, Figure E14.
Description	A unique alphanumeric identifier for a specific WPS.

2.21 type **welding_process_type**

Diagram	
Children	**arc_welding_process** **brazing_process** **other_welding_process** **oxyfuel_gas_welding_process** **allied_process** **resistance_welding_process** **soldering_process** **solid_state_welding_process**
Used By	element **variables_specification/welding_process**
Source	AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes.
Description	Broad classification of the welding process.

*2.21.1 element welding_process_type/**arc_welding_process***

Type	**arc_welding_processes**
Values	enumeration atomicHydrogenWelding(AHW) enumeration bareMetalArcWelding(BMAW) enumeration carbonArcWelding(CAW) enumeration carbonArcWeldingGas(CAW-G) enumeration carbonArcWeldingShielded(CAW-S) enumeration electrogasWelding(EGW) enumeration electroSlagWelding(ESW) enumeration gasMetalArcWelding(GMAW) enumeration gasTungstenArcWelding(GTAW) enumeration plasmaArcWelding(PAW) enumeration shieldedMetalArcWelding(SMAW) enumeration studArcWelding(SW) enumeration submergedArcWelding(SAW) enumeration submergedArcWeldingSeries(SAW-S)

Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

*2.21.2 element welding_process_type/**brazing_process***

Type	**brazing_processes**
Values	enumeration block_brazing(BB) enumeration diffusion_brazing(CAB) enumeration dip_brazing(DB) enumeration exothermic_brazing(EXB) enumeration flow_brazing(FLOW) enumeration furnace_brazing(FB) enumeration induction_brazing(IB) enumeration infrared_brazing(IRB) enumeration resistance_brazing(RB) enumeration torch_brazing(TB) enumeration twin_carbon_arc_brazing(TCAB)
Description	See AWS 3.0-94 p. 100, 101

*2.21.3 element welding_process_type/**other_welding_process***

Type	**other_welding_processes**
Values	enumeration electron_beam_welding(EBW) enumeration electroslag_welding(ESW) enumeration flow_welding(FLOW) enumeration induction_welding(IW) enumeration laser_beam_welding(LBW) enumeration percussion_welding(PEW) enumeration thermite_welding(TW)
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

*2.21.4 element welding_process_type/**oxyfuel_gas_welding_process***

Type	**oxyfuel_gas_welding_processes**
Values	enumeration air_acetylene_welding(AAW) enumeration oxyacetylene_welding(OAW) enumeration oxyhydrogen_welding(OHW) enumeration pressure_gas_welding(PGW)
Description	See AWS 3.0, Figure 54A – Master Chart of Welding and Allied Processes

*2.21.5 element welding_process_type/**allied_process***

Type	**allied_processes**
Values	enumeration oxygen_cutting(OC) enumeration arc_cutting(AC) enumeration other_cutting
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

*2.21.6 element welding_process_type/**resistance_welding_process***

Type	**resistance_welding_processes**
Values	enumeration flash_welding(FW) enumeration projection_welding(PW) enumeration resistance_spot_welding(RSW) enumeration resistance_weam_welding(RSEW) enumeration upset_welding(UW)
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

*2.21.7 element welding_process_type/**soldering_process***

Type	**soldering_processes**
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

*2.21.8 element welding_process_type/**solid_state_welding_process***

Type	**solid_state_welding_processes**
Values	enumeration coextrusion_welding(CEW) enumeration cold_welding(CW) enumeration diffusion_welding(DFW) enumeration explosion_welding(EXW) enumeration forge_welding(FOW) enumeration friction_welding(FRW) enumeration hot_pressure_welding(HPW) enumeration ultrasonic_welding(USW)
Description	See AWS 3.0, Figure 54A - Master Chart of Welding and Allied Processes

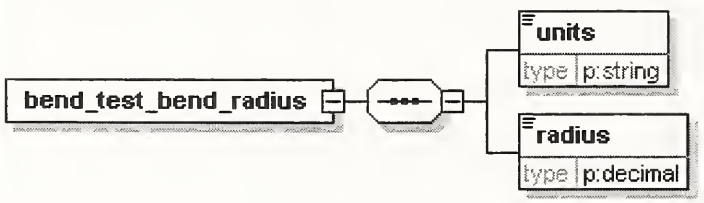
3. Testing and Inspection Data

Terms typically used in inspection applications that already appear in the previous sections will not be duplicated in this section. The scope is data that is essential to reporting results of tests. In addition, some fields were added that are found on test results forms that are essential for record keeping and for tracing the source of results. Example data are testing machine type, model and serial number, technician running the test, and date of test.

The scope of this data dictionary addresses mechanical testing, but not non-destructive (e.g., Welding Handbook, Vol. 1, p. 213), metallurgical or compositional testing. These areas need to be documented for complete coverage of weld testing procedures and their results.

3.1 element **bend_test_bend_radius**

Diagram



Children	**units** **radius**
Source	AWS B4.0, section A1-9(6)
Description	Radius of the plunger or mandrel used in a bend test.

*3.1.1 element bend_test_bend_radius/**units***

Type	enumeration of p:string
Values	enumeration millimeters enumeration inches
Description	Choice of U.S. Customary or SI units.

*3.1.2 element bend_test_bend_radius/**radius***

Type	linear_dimension_type_mm
Description	The numerical value.

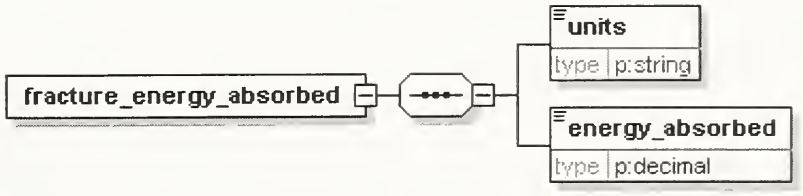
3.2 type **bend_test_types**

Type	enumeration of p:string
Values	enumeration transverse_side_bend enumeration transverse_face_bend enumeration transverse_root_bend enumeration longitudinal_face_bend enumeration longitudinal_root_bend enumeration fillet_weld_root_bend enumeration surfacing_weld_face_bend enumeration surfacing_weld_side_bend
Source	AWS B4.0, section A1-7
Description	Classification of bend test specified.

3.3 element **fracture_crack_plane_orientation**

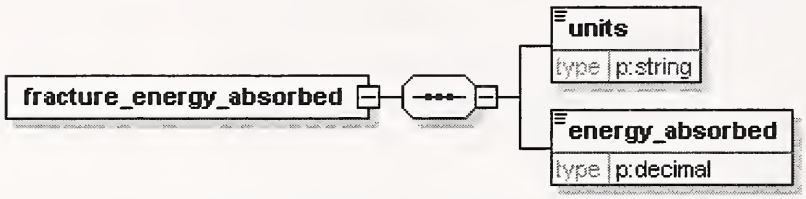
Type	p:string
Source	AWS B4.0, section A3-9
Description	Location of the fracture in relation to the weld.

3.4 element **fracture_energy_absorbed**

Diagram	
Children	**units** **energy_absorbed**
Source	AWS B4.0, section A3-9.1(10).

Description	In a fracture toughness test, the energy consumed in breaking the specimen.

*3.4.1 element fracture_energy_absorbed/**units***

Diagram	
Type	enumeration of p:string
Values	enumeration joules enumeration foot_pounds
Description	Choice of U.S. Customary or SI units.

*3.4.2 element fracture_energy_absorbed/**energy_absorbed***

Type	p:decimal
Description	The value of the test result.

3.5 element **fracture_machine_notch_position**

Type	p:string
Source	AWS B4.0, section A3-9
Description	Location of the machined notch.

3.6 element **fracture_specimen_location**

Type	p:string
Source	AWS B4.0, section A3-9
Description	Area of the weldment the specimen was cut from.

3.7 type **fracture_toughness_test_methods**

Type	enumeration of p:string
Values	enumeration charpy_v_notch_E_23 enumeration dynamic_tear_E_604 enumeration plane_strain_E_399 enumeration drop_weight_nil_ductility_temp_E_208
Source	AWS B4.0, section A3.1
Description	Name of the specific ASTM test specified.

3.8 type **fracture_type_of_test_equipment**

Type	p:string
Source	AWS B4.0, section A3-9

Description	Mechanical configuration of test machine used, to conform to a specified test method.

3.9 element **hardness_indentor**

Type	p:string
Source	AWS B4.0, section C2-9(7)
Description	Specification for the indentor used in the test. This is one data element of a test report.

3.10 element **hardness_load**

Type	p:decimal
Source	AWS B4.0, section C2-9(7)
Description	The force load used in the test, units must be specified. This is one data element of a test report.

3.11 element **hardness_location_of_impressions**

Type	p:string
Source	AWS B4.0, section C2-9(8)
Description	Description of locations of multiple test impressions.

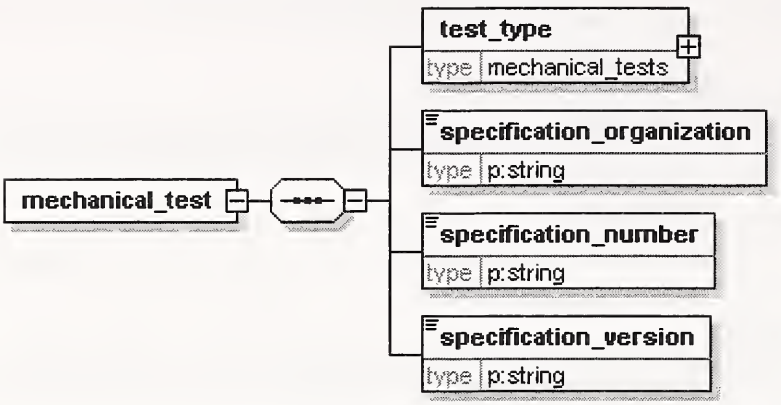
3.12 element **hardness_test_result**

Source	AWS B4.0, section C219.(10).
Description	The numerical hardness value obtained by the test.

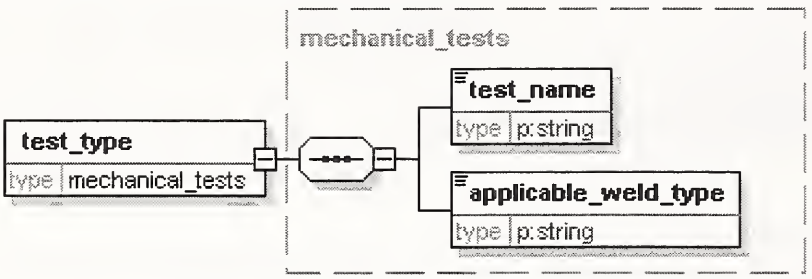
3.13 element **hardness_test_types**

Type	enumeration of p:string
Values	enumeration brinell_E_10 enumeration rockwell_E_18 enumeration vickers_E_92 enumeration Knoop enumeration vickers_E_384 enumeration portable_hardness_E_110 enumeration other_rockwell
Source	AWS B4.0, section C2-4
Description	The name of the test specified or required.

3.14 element **mechanical_test**

Diagram	
Children	**test_type specification_organization specification_number specification_version**
Source	AWS B4.0:2000, ANSI/AWS A9.2.
Description	A destructive test done to determine properties of a weld.

*3.14.1 element mechanical_test/**test_type***

Diagram	
Type	**mechanical_tests**
Children	**test_name applicable_weld_type**
Description	Category of test required or performed.

*3.14.2 element mechanical_test/**specification_organization***

Type	**p:string**
Source	ANSI/AWS A9.2. sections 5.1.1.1, 5.2.1.1, 5.3.1.1

*3.14.3 element mechanical_test/**specification_number***

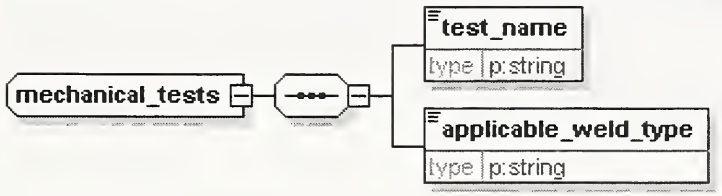
Type	**p:string**
Source	ANSI/AWS A9.2. sections 5.1.1.2, 5.2.1.2, 5.3.1.2

*3.14.4 element mechanical_test/**specification_version***

Type	p:string

Source	ANSI/AWS A9.2. sections 5.1.1.3, 5.2.1.3, 5.3.1.3
Description	The version of the test method used.

3.15 type **mechanical_tests**

Diagram	
Children	**test_name** **applicable_weld_type**
Used By	element **mechanical_test/test_type**
Source	AWS B4.0:2000
Description	Name of test type and the weld type being evaluated.

*3.15.1 element mechanical_tests/**test_name***

Type	enumeration of p:string
Values	enumeration bend enumeration face_bend enumeration root_bend enumeration side_bend enumeration tension enumeration fracture_toughness enumeration longitudinal_guided_bend enumeration soundness enumeration shear enumeration nick_break enumeration hardness enumeration stud_weld enumeration controlled thermal_severity enumeration cruciform enumeration implant enumeration lehigh_restraint enumeration varestraint enumeration oblique_y_groove
Source	AWS B4.0:2000

*3.15.2 element mechanical_tests/**applicable_weld_type***

Type	enumeration of p:string
Values	enumeration groove_weld enumeration fillet_weld enumeration groove_and_fillet_welds

	enumeration stud_weld enumeration weldability_test
Description	AWS B4.0 classifies tests by weld Type, ie groove, fillet, stud, etc.

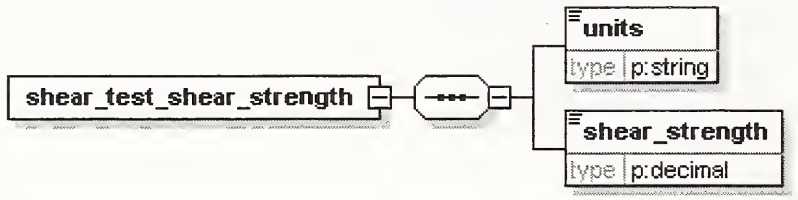
3.16 element **nick_break_apparatus**

Type	enumeration of p:string
Values	enumeration fracture_by_hammer enumeration loading_in_tension enumeration three_point_bending
Source	AWS B4.0, section C1-6
Description	Type of test performed

3.17 type **shear_specimen_types**

Type	enumeration of p:string
Values	enumeration longitudinal enumeration transverse
Source	AWS B4.0, section B3-7
Description	Orientation of the specimen to that of the sampled weld.

3.18 element **shear_test_shear_strength**

Diagram	
Children	**units** **shear_strength**
Source	AWS B4.0, section B3-9(5)
Description	The numerical results from a shear test.

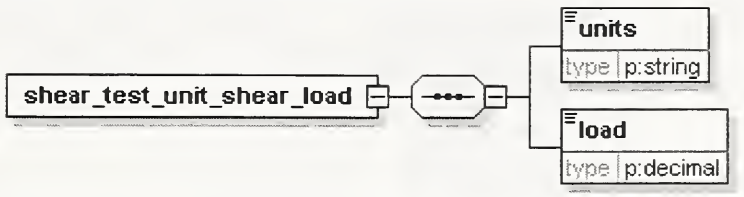
*3.18.1 element shear_test_shear_strength/**units***

Type	p:string
Description	SI or U.S. customary units.

*3.18.2 element shear_test_shear_strength/**shear_strength***

Type	p:decimal
Description	Numerical results of the test.

3.19 element **shear_test_unit_shear_load**

Diagram	
Children	**units** **load**
Source	AWS B4.0, section B3-9(4)
Description	Numerical results of the test.

*3.19.1 element shear_test_unit_shear_load/**units***

Type	p:string
Description	Choice of U.S. Customary or SI system.

*3.19.2 element shear_test_unit_shear_load/**load***

Type	p:decimal
Description	Numerical value of the test result.

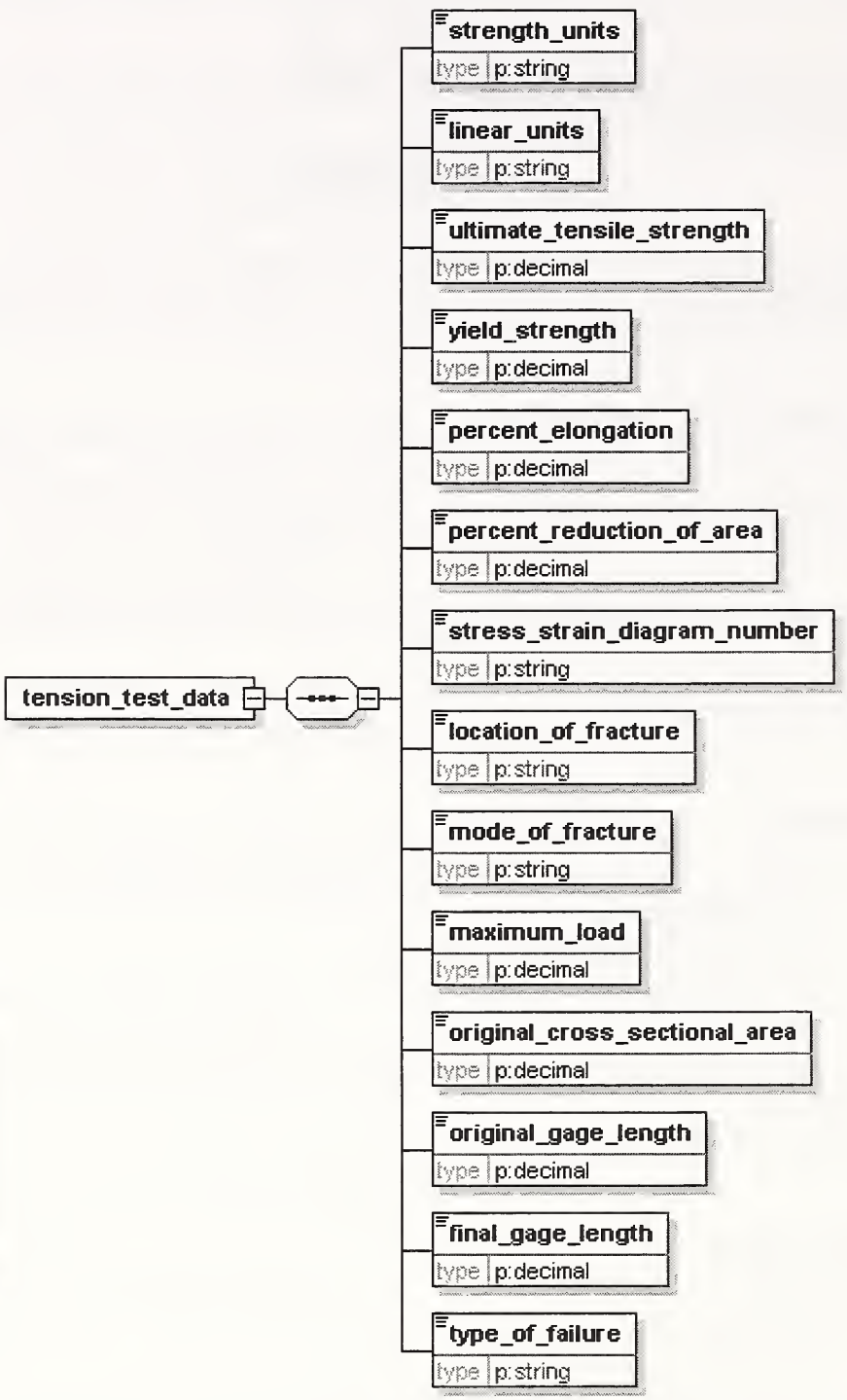
3.20 type **soundness_test_types**

Type	enumeration of p:string
Values	enumeration fillet_weld_break_proc_qual enumeration fillet_weld_break_primer_coated_p_q enumeration fillet_weld_break_galv_proc_qual enumeration fillet_weld_break_welder_qual enumeration fillet_weld_break_tack_welder_qual
Source	AWS B4.0, section B2-7
Description	Criterion for using the results of the test.

3.21 type **tension_specimen_types**

Type	enumeration of p:string
Values	enumeration round_all_weld_metal_type enumeration round_transverse_type enumeration rectangular_transverse_type enumeration rectangular_longitudinal_type enumeration tubular_type
Source	AWS B4.0, section A2-7.
Description	Description of shape of the specimen and where in the weld it was taken.

3.22 element **tension_test_data**

Diagram	
Children	**strength_units linear_units ultimate_tensile_strength yield_strength percent_elongation percent_reduction_of_area stress_strain_Diagram_number location_of_fracture mode_of_fracture maximum_load original_cross_sectional_area original_gage_length final_gage_length type_of_failure**
Source	AWS B4.0, section A2-4
Description	The physical quantities measured by testing a groove weld using ASTM procedures for tension testing.

*3.22.1 element tension_test_data/**strength_units***

Type	Enumeration of p:string
Description	Choice of SI or U.S. Customary units.

*3.22.2 element tension_test_data/**linear_units***

Type	enumeration of p:string
Values	enumeration millimeters enumeration inches
Description	Choice of SI or U.S. Customary units.

*3.22.3 element tension_test_data/**ultimate_tensile_strength***

Type	p:decimal
Description	Highest engineering stress in the material before rupture.

*3.22.4 element tension_test_data/**yield_strength***

Type	p:decimal
Description	Maximum stress that can be induced before the material goes plastic.

*3.22.5 element tension_test_data/**percent_elongation***

Type	p:decimal
Description	A measure of ductility, the change in gage length divided by the original length times 100.

*3.22.6 element tension_test_data/**percent_reduction_of_area***

Type	p:decimal
Description	Difference between the original cross sectional area and the smallest specimen cross section after testing.

*3.22.7 element tension_test_data/**stress_strain_Diagram_number***

Type	p:string
Description	Drawing number of the plot of stress versus strain test results.

*3.22.8 element tension_test_data/**location_of_fracture***

Type	enumeration of p:string
Values	enumeration unaffected base metal enumeration weld metal enumeration heat affected zone

Description	Type of material in the specimen where the fracture occurred.

*3.22.9 element tension_test_data/**mode_of_fracture***

Type	p:string
Description	Mechanics of material deformation that caused the fracture.

*3.22.10 element tension_test_data/**maximum_load***

Type	p:decimal
Description	Maximum force exerted on the specimen during the test.

*3.22.11 element tension_test_data/**original_cross_sectional_area***

Type	p:decimal
Description	Area of the specimen before testing.

*3.22.12 element tension_test_data/**original_gage_length***

Type	p:decimal
Description	Length of the specimen before testing.

*3.22.13 element tension_test_data/**final_gage_length***

Type	p:decimal
Description	Specimen length after testing, measured to determine elongation.

*3.22.14 element tension_test_data/**type_of_failure***

Type	enumeration of p:string
Values	enumeration ductile enumeration brittle
Source	AWS B4.0, section A2-9
Description	Broad category of failure.

3.23 element **test_fracture_appearance**

Type	p:string
Source	AWS B4.0, section A3-9
Description	Visible evidence of the fracture.

3.24 element **test_fracture_location**

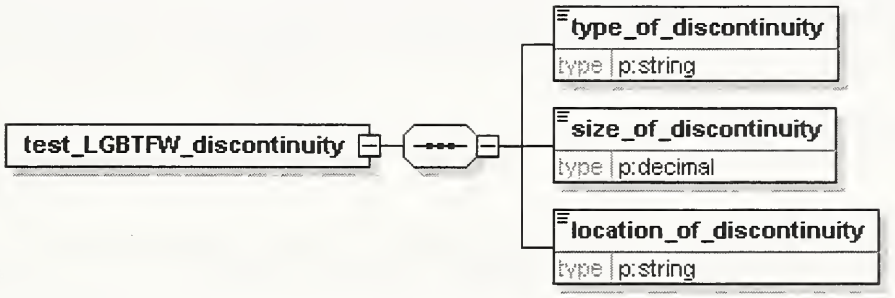
Type	p:string

Source	AWS B4.0, section A3-9.
Description	Area of failure relative to the weld.

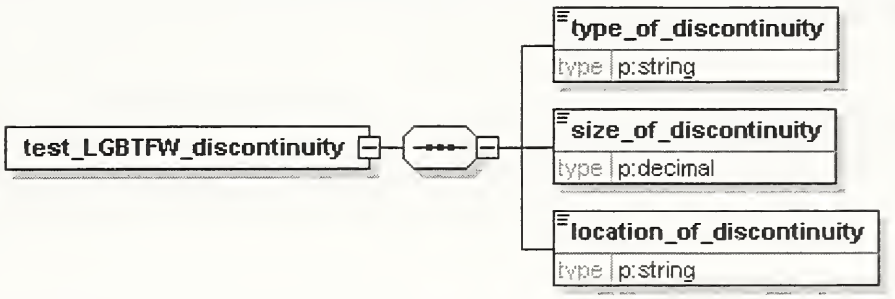
3.25 element **test_LGBTFW_angle_of_fracture**

Type	p:string
Source	AWS B4.0, section B1-9(6)
Description	Longtitudinal guided-bend test for fillet welds, angle of fracture.

3.26 element **test_LGBTFW_discontinuity**

Diagram	
Children	**type_of_discontinuity** **size_of_discontinuity** **location_of_discontinuity**
Source	AWS B4.0, section B1-9(5).
Description	Description of discontinuity caused by longitudinal guided-bend test for fillet welds.

*3.26.1 element test_LGBTFW_discontinuity/**type_of_discontinuity***

Diagram	
Type	p:string
Description	Type of the failure.

*3.26.2 element test_LGBTFW_discontinuity/**size_of_discontinuity***

Type	p:decimal
Description	Editor's note: Is this a quantitative measure or observation of relative size? Need units specified if it is a measurement.

*3.26.3 element test_LGBTFW_discontinuity/**location_of_discontinuity***

Type	p:string

Description	Location in relation to the weld.

3.27 element **test_machine_serial_number**

Type	p:string
Description	Serial number to identify the machine that produced the test results.

3.28 element **test_number_of_specimens**

Type	p:integer
Source	AWS B4.0
Description	The number of specimens of a single weld required for a test.

3.29 element **test_percent_elongation**

Type	p:decimal
Source	AWS B4.0, section A1, 1.4
Description	In a tension test, the ratio of the change in length to the initial length.

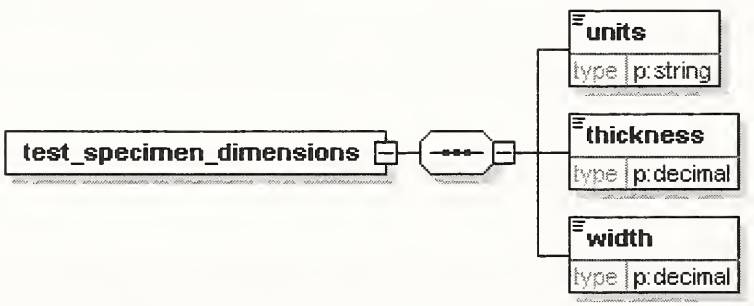
3.30 element **test_postweld_mechanical_treatment**

Type	p:string
Description	Any physical working of the weld specimen before testing.

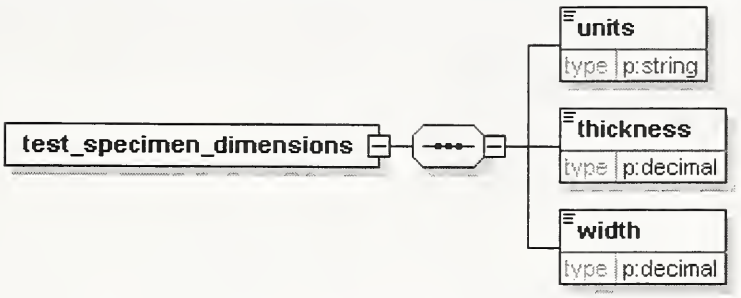
3.31 element **test_postweld_thermal_treatment**

Type	p:string
Source	AWS B4.0, section A1-1.3
Description	Times and temperatures of heat treatment after welding. It is possible this element should be further decomposed if it's information can be structured.

3.32 element **test_specimen_dimensions**

Diagram	
Children	**units thickness width**
Source	AWS B4.0
Description	Dimensions of the specimen before testing. Editor's note: For specific Types of tests only?

*3.32.1 element test_specimen_dimensions/**units***

Diagram	
Type	enumeration of p:string
Values	enumeration millimeters enumeration inches
Description	Choice of U.S. Customary or SI units.

*3.32.2 element test_specimen_dimensions/**thickness***

Type	p:decimal
Description	Thickness of the specimen before testing.

*3.32.3 element test_specimen_dimensions/**width***

Type	p:decimal
Description	Width of the specimen before testing.

3.33 element **test_specimen_location**

Type	p:string
Source	AWS B4.0, section A1, 1.3, 1.4
Description	Where in the weldment/joint/weld the specimen was cut.

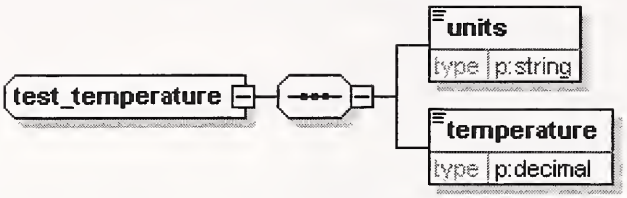
3.34 element **test_specimen_orientation**

Type	enumeration of p:string
Values	enumeration longitudinal enumeration transverse
Source	AWS B4.0M, p. 1
Description	The relationship of the axis of the test specimen to the axis of the weld.

3.35 element **test_technician_name**

Type	p:string
Source	Taken from an example of an industry test report.
Description	Name of the person who conducted a test.

3.36 type **test_temperature**

Diagram	
Children	**units temperature**
Source	AWS B4.0
Description	Temperature of a specimen at the time of test.

*3.36.1 element test_temperature/**units***

Type	enumeration of p:string
Values	enumeration degrees_celsius enumeration degrees_fahrenheit
Description	Choice of SI or U.S. Customary units celsius or fahrenheit.

*3.36.2 element test_temperature/**temperature***

Type	p:decimal

Acknowledgments

The technical information came primarily from American Welding Society documents that were generated by hundreds of experts in diverse fields. This document is an extension of two 1992 AWS documents, "A9.1" and "A9.2" that were written by the AWS A9 committee then chaired by Jerry E. Jones. Tom Siewert has for some time encouraged the pursuit of a standard data specification for welding data. Tim Quinn had extensive technical input to this document. Christopher Pepper helped edit the document.

Appendices

Appendix 1 – Items to Add in Next Edition of Data Dictionary

Design

- three dimensional geometric location of weld (including weld begin, end points, contour), weld length.
- information to describe the required accuracy of cutting of base materials (e.g., cutting, flame cutting, laser cutting), and accuracy of edge preparation, e.g., whether machining is required, or if flame cutting is adequate.
- tubular joints, e.g., Welding Handbook, Vol. 1, p. 174.

Process

- items needed to describe PQR or WPS ranges, minimum and maximum values, required processes (e.g., "preheat required"), prohibited status (e.g., "consumable inserts are not permitted", or optional conditions.
- non-arc welding process details.

Inspection

- crack types from AWS 3.0 Figure 33, p. 83, and weld discontinuities - Figure 32. These would be used in a visual inspection report.
- welding test positions from AWS 3.0 – Figures 18 and 19.
- non-destructive examination (NDE) parameters and results.
- AWS D14.6, *Specification for Welding of Rotating Elements of Equipment,* is a rich source of welding terms and variables that should eventually be covered.

Note – AWS D14.6

Appendix 2 - Tasks for data modelers

This data dictionary is not sufficiently rich to specify a data base design or a data format. Some of the tasks needed for detailed design are listed below.

- Strengthen relationships of data elements, i.e. grouping elements into reusable chunks and choosing exact encodings of data types and their values (e.g., values for enumerated data). This will be the job of data modelers. They will test the data model for completeness by using scenarios of data flow from industrial welding facilities.
- Harmonize the AWS data model with any that may be developed in specific industries. The "CIMSteel Integration Standard", described at http://www.cis2.org, and http://www.coa.gatech.edu/~aisc/ is an example.
- Specify optional and required data that is dependent on other data – e.g., if base metal is a tube, then "diameter" is required information. For example, if the process is automatic GMAW, gas composition is required data and an electrode size is incorrect data. For example, if "backing_used" is true, then there must be data in "backing_type" – if "backing_used" is false, there cannot be data in the "backing_type" field.
- Allow users to deal easily and unambiguously with U.S. Customary and/or SI units, and also within each of these, a choice of multiple unit scales, e.g., for linear speed, inches/second or feet/minute.
- Decide whether to specify enumerations or to allow free use of text fields. E.g., joint types could be a string field, or an single choice among enumerated values in the specification.
- Specify data types to handle e.g., min/max values of variables in SWPSs and PQRs. Also specify actual ranges that are legal or allowed if appropriate.
- Modularize definitions for maximum reuse in different report forms, and also to reduce the number of elements to aid understandability. For example, many fields from WPSs are used in mechanical test results forms in reporting the processes and weld design that produced the weld.
- Pick encoding options to allow extensibility of data, to allow for conditions not anticipated by the modelers, or to use data unique to a company or a proprietary process. However users are

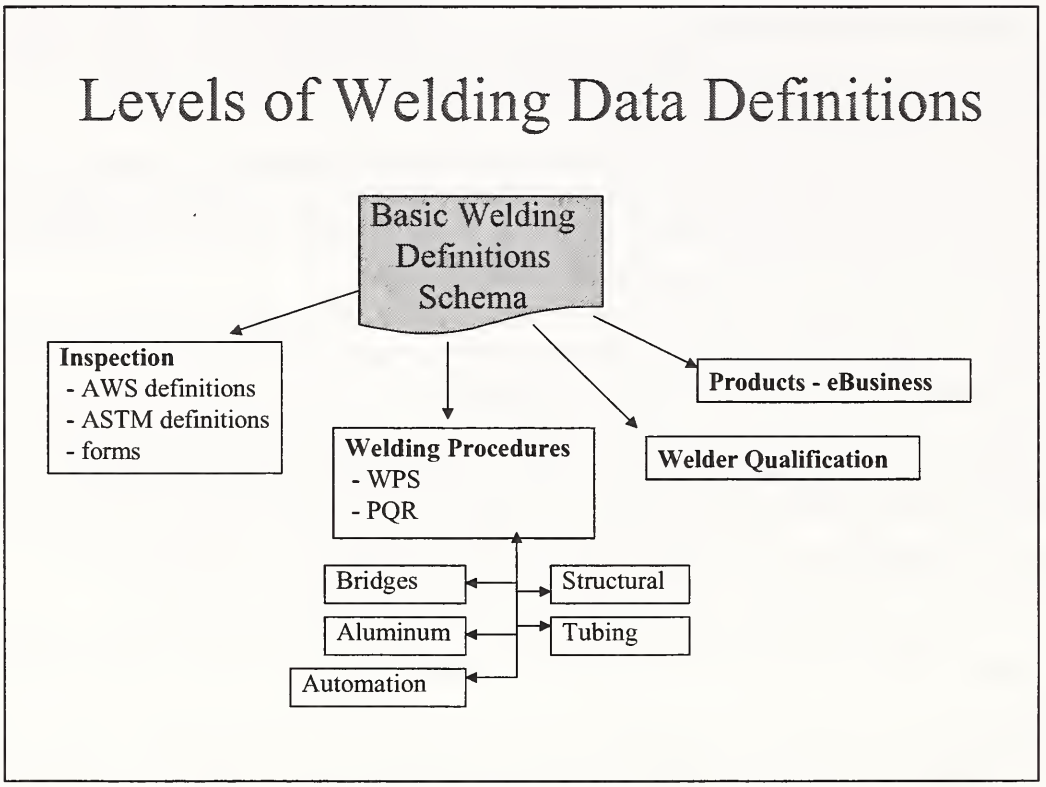
encouraged to fit their applications within the guidelines of the data models as much as possible, minimizing their use of "other" data types.

- Fine tune definitions and rules for specific standard reports, e.g., mechanical testing results.
- Eliminate duplicate items, in the interest of computational efficiency and understandability.

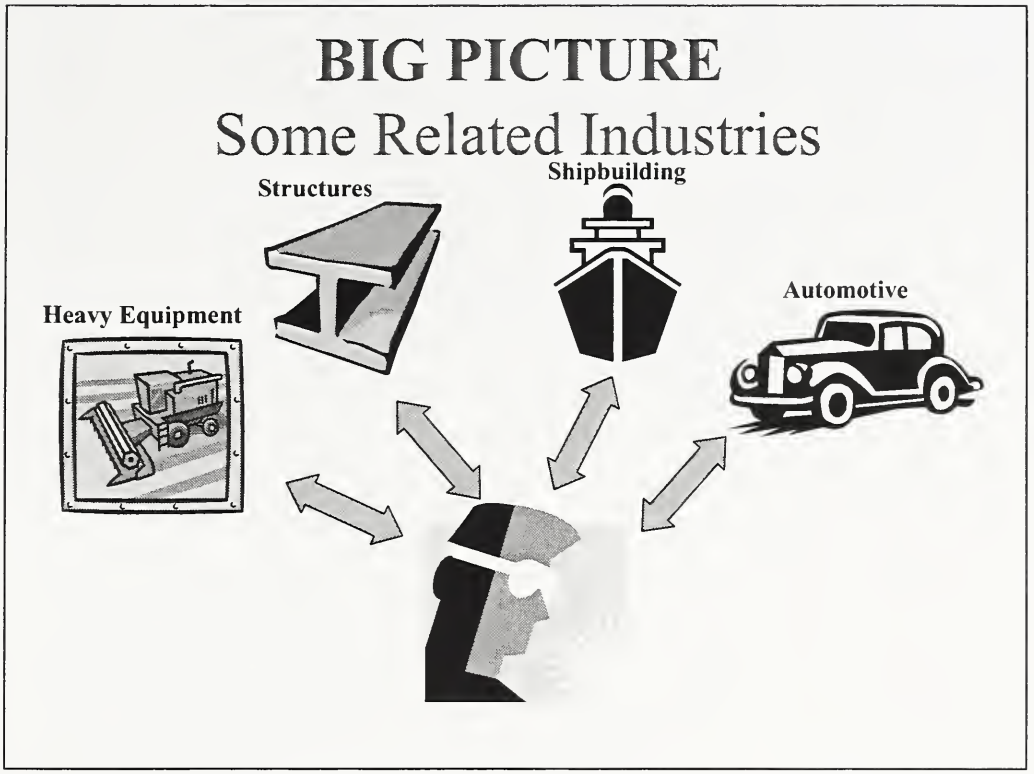
If an effort goes forward to develop formal data schema, the modelers will cooperate with members of the various AWS committees that authored standards documents to ensure correct interpretation of the data, use of familiar terms, and design of comprehensive and unambiguous enumerations where appropriate.

- Add data elements that welding experts deem required, that are not specified in the AWS documents. E.g., some companies record the serial number of the testing machine used, and the name of the testing technician.
- Pick default values from the enumerated choices (a very detailed decision).

Appendix 3 – The BIG PICTURE of welding data exchange



Modularization of welding specifications (instead of pursuing all these areas in a single effort) will speed progress in each smaller area, and allow experts to contribute their knowledge in narrower areas more efficiently.



Many manufacturing industries share welding as a fabrication process. The data dictionary helps define welding variables centrally so the industries can "borrow" them, instead of each industry developing their own definitions. The goal is to avoid development of different "dialects" of data formats that the welding industry would have to accommodate.

Appendix 4 – Terminology differences between ISO and AWS

1. ISO does not use the word "flange" in describing joints. It uses "edges turned up".
2. ISO does not describe "groove welds". It uses "butt weld" hyphenated with the name of the groove type.